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CANADIAN GEOGRAPHICAL JOURNAL

UNIVERSITY OF MICHIGAN
APR 23 1957
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As one of its major activities in carrying out its purpose, the Society publishes a monthly magazine, the Canadian Geographical Journal, which is devoted to every phase of geography — historical, physical and economic — of Canada, of the British Commonwealth and of the other parts of the world. It is the intention to publish articles in this magazine that will be popular in character, easily read, well illustrated, and informative.

The Canadian Geographical Journal will be sent to each member of the Society in good standing. Membership in the Society is open to any one interested in geographical matters. The annual fee for membership is five dollars (Canadian currency).

The Society has no political or other sectional associations, and is responsible only to its members. All money received is used in producing the Canadian Geographical Journal and in carrying on such other activities for the advancement of geographical knowledge as funds of the Society may permit.

CANADIAN GEOGRAPHICAL JOURNAL

Published monthly by
THE CANADIAN GEOGRAPHICAL SOCIETY
Ottawa, Ontario
Editor - GORDON M. DALLYN

This magazine is dedicated to the presentation in authentic and popular form, with extensive illustrations, of the broad pattern of Canadian life and its industrial, physical, and cultural foundations.

The articles in this Journal are indexed in the *International Index to Periodicals* and in the *Canadian Index*.

The British standard of spelling is adopted substantially as used by the Government of Canada and taught in most Canadian schools, the precise authority being the Concise Oxford Dictionary, fourth edition, 1951.

Address all communications regarding change of address, non-delivery of Journal, etc., to the publication office, 1000 St. Antoine St., Montreal 3, Canada, giving old and new address. On all memberships, the expiry date will be printed on wrapper. This will constitute a receipt for subscription.

Membership dues of The Canadian Geographical Society, which include postpaid delivery of the Journal, are $5.00 per year in any country, payable at par in Ottawa. All remittances should be sent to Head Office.

Member Audit Bureau of Circulations

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Photograph by Richard Harrington

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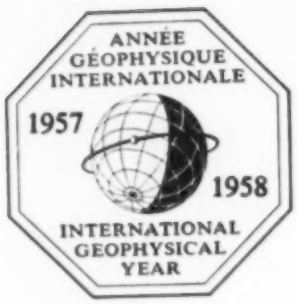


The International Geophysical Year

by W. J. MACKEY

THE International Geophysical Year (I.G.Y.) is a concerted effort by more than 5,000 scientists to obtain a unified picture of our physical environment. Since the plan of the I.G.Y. was proposed in 1950, fifty-five nations have joined in this vast enterprise, which will cost at least $500,000,000, possibly much more than that. Experts in fourteen fields of learning will investigate the earth from pole to pole, from its liquid core to outer space.

In science, the I.G.Y. will climax the efforts of many centuries to solve mysteries of the earth and the sun. In human affairs, it is heralded as a symbol of goodwill among nations.

From July 1957 through December 1958 simultaneous measurements will be taken all over the earth of such phenomena as the aurora, cosmic rays, meteors, the ionosphere, glaciers, ocean tides and currents, gravity, magnetism, earth tremors, solar flares and sun-spots. Something like twenty years of normal research will be compressed into a period of eighteen months.

There are two reasons for the global plan of attack. First, isolated measurements, even in many places, fail to produce a full picture of the earth's forces. Second, these forces are themselves variable, or are complicated by other phenomena. Geophysicists will make observations in all parts of the world at the same time, and the measurements will take into account other natural events which may affect the results. The final data will then be complete and meaningful, accurately co-ordinated in space and time.

The earth, together with its atmosphere, oceans, magnetism and gravity, is a complex of related phenomena which are either caused or influenced by the sun's energy. A study of the earth must include a study of the sun as well. For this reason the I.G.Y. is set for a time approaching sun-spot maximum, when unusual effects of the sun are more pronounced.

The eighteen-month span of the studies will allow for observations during a number of expected solar flares. It will bridge several important periods such as equinoxes and solstices, and will include a sun's eclipse which will be seen in the south polar regions. The eighteen months will also provide for two summers in Antarctica, an area which is especially interesting but brutally hostile. Serious preparations began in the Antarctic during the austral summer of 1954-5.

The I.G.Y. is not a new idea. International studies of geophysical problems began seventy-five years ago. The I.G.Y. is the third in a series of such investigations which began with the First International Polar Year in 1882-3, and were carried forward in the Second Polar Year in 1932-3. New features of the I.G.Y., however, are its greatly expanded scale of operations, which now include the entire earth; its expanded interests, which now cover fourteen departments of research; its fully international support, involving more than fifty countries; and its new or improved techniques in photography, spectroscopy, radar and rocketry.

The newest and most dramatic among the I.G.Y.'s research instruments is the earth satellite — man's first device for observing his own planet from outer space. Less spectacular but very significant is the recent development in electronic computers. Without these mechanical brains the intricate mass of data which will come out of the I.G.Y. could scarcely be handled. Though not new in principle, the I.G.Y. is by far the greatest study of the earth

ever undertaken; it is also the most ambitious scientific project ever to be launched on an international basis.

What will scientists get from the I.G.Y. ? In the main, they will have clearer answers to many questions, some of immediate practical value, others of more long-term significance.

Those who stand to gain here and now are the scientists who deal with weather forecasting, who operate radio and telephone systems, and who are developing various other services which are based on magnetism, gravity, oceanography and seismology. This will result in benefits to irrigation and agriculture, ocean fisheries, shipping, air transportation, communications, photographic surveys, radar and electronics, and geophysical exploration for oil and minerals.

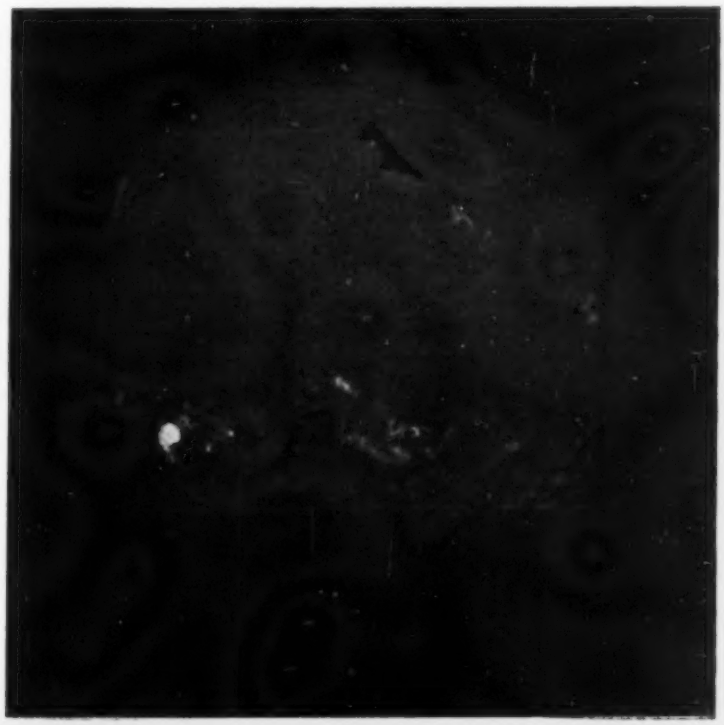
Eventually the contributions of the I.G.Y. are likely to be immense. Today, great advances in technology are following more and more closely after theoretical science. From the I.G.Y. studies the solutions of many problems are already foreshadowed. Some of these are: disposal of atomic wastes, productivity of the oceans, long-range prediction of ocean levels and climatic changes, exploration and resources development in the Antarctic, new knowledge of mineral deposits and their distribution, and prediction of earthquakes and volcanic eruptions.

First and last, however, the I.G.Y. is scientific — looking for the explanation of things, to learn why and how they happen. The greatest potential of the study may lie in the unexpected; something of unusual significance may be revealed, which in ten or twenty years will lead to a major scientific discovery. One can only speculate: scientists are interested in new sources of power, new knowledge of atomic nuclei, new principles of communication, and new dimensions of travel. The frontiers of physics will be extended and the earth's forces better understood. No one can predict the uses of this new knowledge. Much human progress has been based on facts which had no material value at the time of their discovery.

Organization

Officially the I.G.Y. is sponsored by a world organization known as the International Council of Scientific Unions. Since 1953 a small committee of the Council, charged with organizing the I.G.Y., has met at Brussels, Rome and Barcelona, and the main objectives of the program have been set up. Some finances are to come from UNESCO — the educational, scientific and cultural wing of the United Nations. But for the most part each participating country is planning and financing its own program. Some countries will have scientific parties in various parts of the world; others, including Canada, will be fully occupied at home.

Two of the scientific bodies in the International Council have Canadian member groups, both of which are associate committees of the



Photograph of the sun, showing a solar flare (bright spot at lower left). This flare occurred on 8 February 1957, and lasted twenty minutes. Solar flares are violent eruptions in the sun's atmosphere which produce geophysical effects on the earth, such as the aurora and magnetic storms. The I.G.Y. program will include a continuous watch of the sun by observatories around the world.

Dominion Observatory, Ottawa

This map shows the location of the main observation stations in Canada during the International Geophysical Year.

C.G.J. map

National Research Council. These represent Canadian work in geodesy, geophysics, and radio science; but nearly a dozen other fields of science in Canada are equally interested. In fact, the Canadian I.G.Y. program is under an advisory committee which represents all government agencies and university departments engaged in the earth sciences. This advisory committee is sponsored by the National Research Council and under the chairmanship of Mr. F. T. Davies of the Defence Research Board, formerly a member of the Byrd Antarctic Expedition of 1928-30, and head of the Canadian Polar Year Expedition, 1932-3.

The Canadian I.G.Y. is to be administered by an executive committee whose chairman is Dr. D. C. Rose (pure physics), National Research Council. The other members are Dr. C. S. Beals (astrophysics), Dominion Observatory; Mr. F. T. Davies (geophysics), Defence Research Board; and Dr. D. W. R. McKinley (radio physics), National Research Council.

Canada will take part in all departments of the I.G.Y. except two—earth satellites, which are special projects of the Americans and the Russians, and rockets, which will be launched by several countries around the world. Rockets will be fired in Canada, but by the United States experts who are operating at Fort Churchill. The main participating agencies in Canada are as follows:

Defence Research Board (ionosphere physics, solar activity, glaciology),

Department of Mines and Technical Surveys (geomagnetism, solar activity, longitudes and latitudes, oceanography, seismology, gravity, meteor studies),

Department of Transport (ionosphere, telecommunications, meteorology),

National Research Council (aurora and airglow, ionosphere, solar activity, cosmic rays, glaciology, meteors),

Joint Committee on Oceanography (ocean tides, water levels, currents),

University of Alberta (meteorology), Queen's University (ionosphere), University of Saskatchewan (geomagnetism, aurora, ionosphere), University of Toronto (solar activity, glaciology), and the University of Western Ontario (ionosphere).

Among the spectacular features of the I.G.Y. are the Antarctic expeditions, the earth satellites, rocket launchings, and world meteorological chains.

The Antarctic

Twelve nations will investigate the Antarctic, a mountainous land mass of 6,000,000 square miles, much larger than all of Canada. Most of the continent is a vast plateau at an average height of 6,000 feet, capped by the world's greatest ice sheet and feeding more than three-quarters of the world's glaciers. This "ice-box of the world" has a great influence on climate in all countries.

The most costly and hazardous expeditions are those of Britain, the United States and Soviet Russia. The British, aided by a New Zealand party led by Sir Edmund Hillary, will attempt a Trans-Antarctic Expedition, a 2,000-mile trek across the frigid continent, most of it through areas never before seen by man.

A United States party, supplied by a large American base on the edge of the Ross Sea, is already established at the South Pole. Here eighteen men will work through the long Antarctic night, which began in March. This party will be the first to live through an entire winter in Central Antarctica, where temperatures may fall to as low as 100° Fahrenheit below zero.

Soviet engineers have set up a town site at Mirny, facing Australia and across the South Pole from the main United States bases. Mirny is at the foot of the massive Helen Glacier which leads high into the interior towards "the land of inaccessibility", the most difficult part of Antarctica. The Russians hope to set up two inland bases, one near the geographic pole, the other near the magnetic pole. Other countries in the Antarctic are Australia, Argentina, Belgium, Chile, France, Japan, Norway, and South Africa.

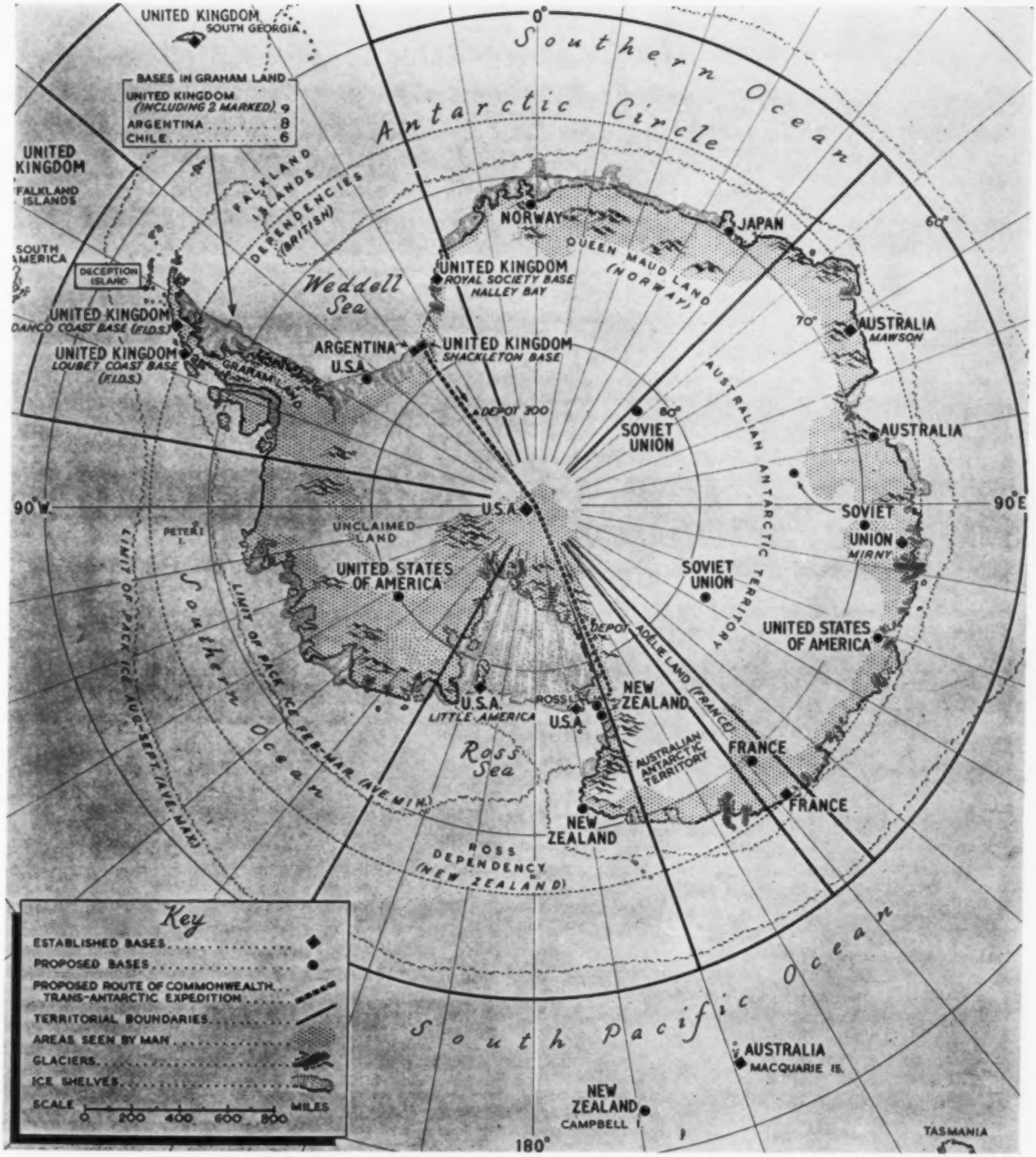
Altogether in the Antarctic, fifty-seven scientific stations will provide full meteorological coverage of the south polar regions. Aerial and ground surveys will map parts of the continent; the gigantic ice sheet, much of it thousands of feet deep, will be drilled and tested for age, temperatures, and evidence of past geologic action. The Antarctic ice sheet is

Her Majesty the Queen talks with Captain Hans Peterson (centre) aboard the Magga Dan, *which carried the British expedition to the Antarctic. Dr. Vivian Fuchs, leader of the Trans-Antarctic Expedition stands at right.*

Right:—Sir Edmund Hillary (right), leader of the New Zealand party of the Trans-Antarctic Expedition, and Bob Miller, deputy leader, dig out a drum of fuel dropped by the party's aircraft on Tasman Glacier, New Zealand. The New Zealand party trained here for the expedition.

Below:—The Falkland Islands Dependencies survey base in the Argentine Islands, off the west coast of Graham Land in the Antarctic.

U.K.I.O. photographs



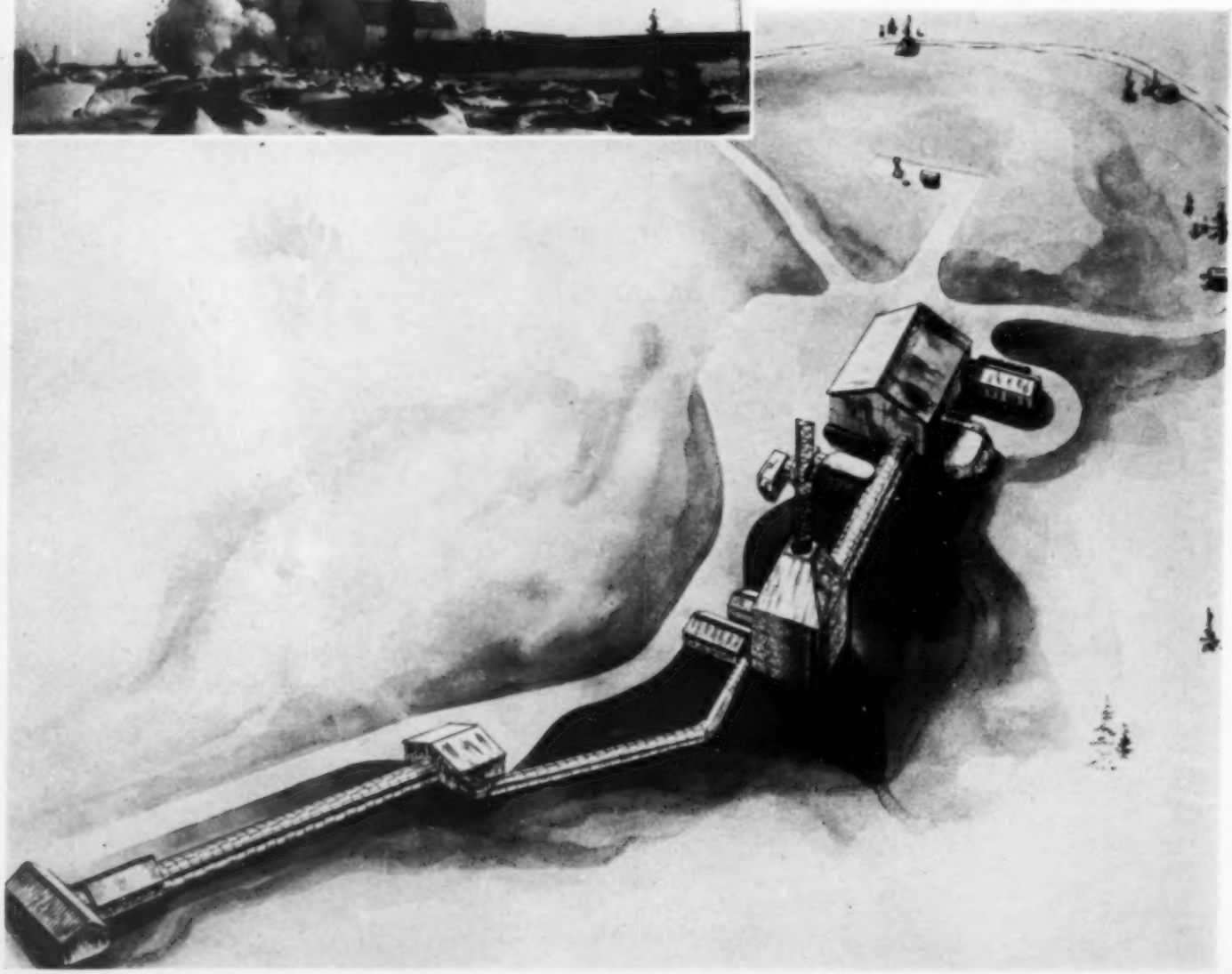
Map reproduced by courtesy of *Discovery* (England)

thought to be one million or more years old. It may give clues to conditions that caused the ice ages to rise and disappear. It may also suggest the rate of melting of the world's ice-caps which now seems to be taking place. What form of land mass lies under the Antarctic ice block is not known, nor how much of it is land and how much sea; but attempts will be made

An Aerobee rocket leaving the launching tower at Fort Churchill on a test firing in November 1956. Measurements by rockets will be taken at heights of 40 to 150 miles.

Below:—Drawing of the rocket launching site at Fort Churchill, Manitoba, The project is part of the United States rocket program, which also includes launchings in the United States, the Pacific and the Antarctic. About forty rockets, mainly Aerobees, will be launched at this site during the I.G.Y. Data obtained will be related to Canadian studies.

U.S. Army photographs



by seismic sounding to explore it, and magnetic instruments will be used to test for minerals.

Man-made Moons

Launching of earth satellites will be the most dramatic and costly single operation of the I.G.Y. In the American project, called "Vanguard", small metal spheres will be boosted beyond the earth's atmosphere by three-stage rockets and set in a predefined orbit with just enough velocity — about 18,000 miles an hour — to keep them within range of ground tracking instruments spaced around the world. A satellite may stay in its elliptical course, ranging from 200 to 800 miles above the earth, for days or even weeks. Loaded with instruments, it will send back radio signals from outer space, and coded measurements of geomagnetism, light intensities, pressures, temperatures, and cosmic ray bombardment.

The United States satellites, to be launched eastwards from the Florida coast, will not be visible in Canada. They will circle the earth near the equator.

Little is known in the West about the Russian satellites. They may be launched in a pole-to-pole trajectory, which would make them visible in Canada for at least part of the time. In any case, Soviet Russia and the United States have agreed to co-ordinate their satellite projects. Radio signals from the satellites will be monitored by both countries.

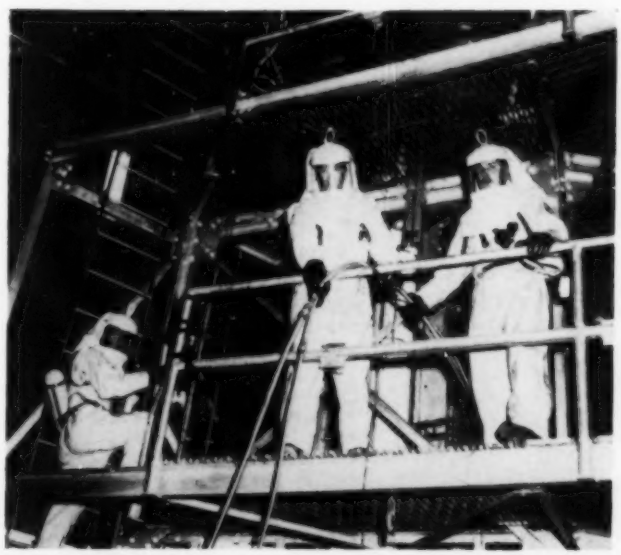
Rockets

Though American scientists experimented during the last war with a small rocket known as *WAC Corporal*, powerful rockets are mainly a development of the German V-2 weapons which bombed England from bases in Holland. Some models are capable of carrying a ton or more of "payload" to a height of over 100 miles. In upper atmosphere studies rockets are now an established research vehicle.

For fifty years, since the ionosphere was discovered, secrets of top layers of the atmosphere have been guarded by the earth's gravity. Sounding balloons are able to ascend only a little above twenty miles. This is still far below the area of rarified gases which is associated with magnetic storms, the aurora, and long-range propagation of radio waves. This semi-vacuum is complicated in structure and constantly affected by solar ultra-violet and X-rays which are shielded from the earth's surface.

Rockets alone can reveal the parts of the sun's radiation which create the different ionospheric layers; or directly measure the aurora, ionospheric currents, high-altitude winds, and the earth's outer magnetic field. During the I.G.Y., rocket-borne instruments at heights of sixty to 180 miles will telemeter to ground-level measurements of pressure, temperature, density, and winds. Chemical compositons of the ionosphere at various levels will be studied by spectrometers; radiation counters will measure the sun's ultra-violet and X-ray intensities, especially during solar flares. During auroral displays the intensity and direction of particle streams will be metered; and the earth's magnetic field will be probed at various latitudes to determine the location and strength of the electrical currents in the ionosphere.

The high costs of heavier types of rockets — up to $100,000 each — at first restricted geophysical research in this field. But recently lighter and cheaper designs have come into wide use. One is the American *Aerobee*, a thirty-foot rocket which can reach a height of 120 miles carrying 150 pounds of equipment. This rocket is assisted initially by a jet booster. Other American types are the *Nike-Cajun*, the *Nike-Deacon*, and the *Dan*, a two-stage rocket capable of sixty-mile heights with fifty pounds of instruments. The French have developed the *Veronique*, similar to the *Aerobee* but not requiring a launching tower. Britain's first high-altitude rocket, the twenty-five-foot *Skylark*,



Fuelling an Aerobee rocket before launching at Fort Churchill. The rocket is propelled by reaction of fuming nitric acid with an aniline alcohol mixture. The fuels, stored in separate tanks in the rocket, unite under pressure in the combustion chamber. U.S. Army

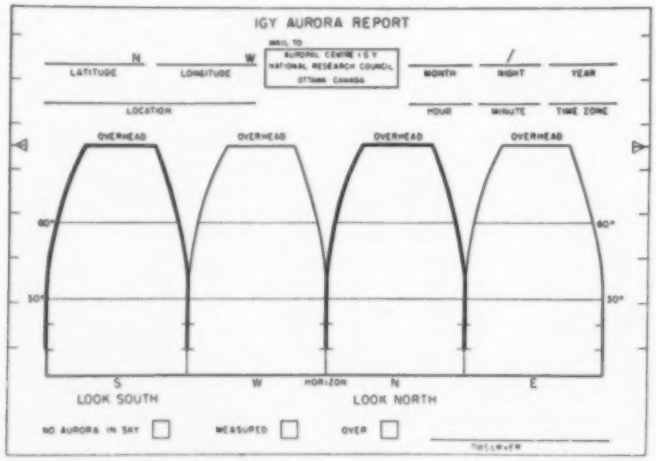
has already been launched at Woomera, Australia. Both the United States and Britain have designed "rockoons", light models which are launched from plastic balloons at altitudes of about fifteen miles and are capable of going up to a height of sixty miles. The Russians and the Japanese will also use rockets during the I.G.Y.

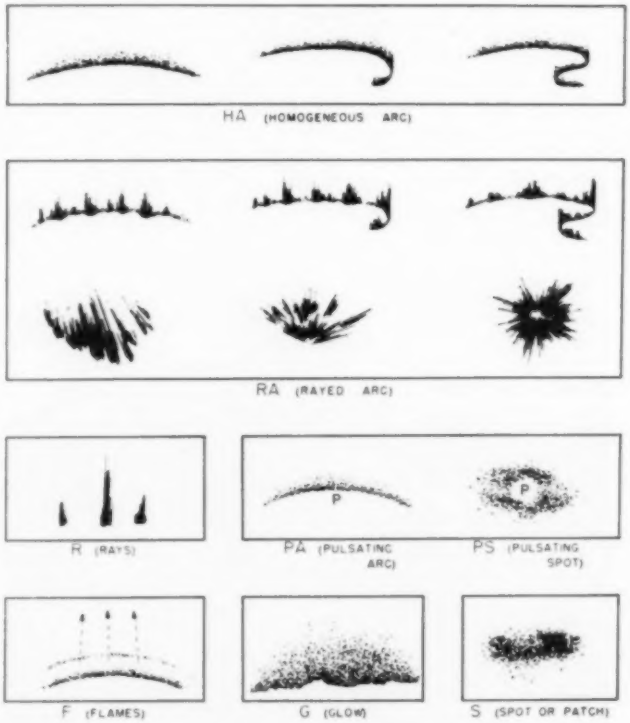
Meridian Chains

The world meteorological chains are three lines of weather observatories stretching halfway around the earth from the Arctic to the Antarctic. One line will pass through Siberia, Japan and Australia; another will traverse Europe and Africa. The third chain, at 80° to 90° West Longitude, will include a number of Canadian meteorological stations. This chain begins on Ellesmere Island, at the most northerly part of Canadian territory, cuts through central Canada just east of Winnipeg, and leaves the United States near Miami, Florida. It then touches Cuba, Panama and Ecuador, follows the west coast of South America (slightly off course), and links up finally with stations in the Antarctic.

From pole to pole, about thirty weather stations will operate on this 90° chain, all of them taking the usual measurements of atmospheric

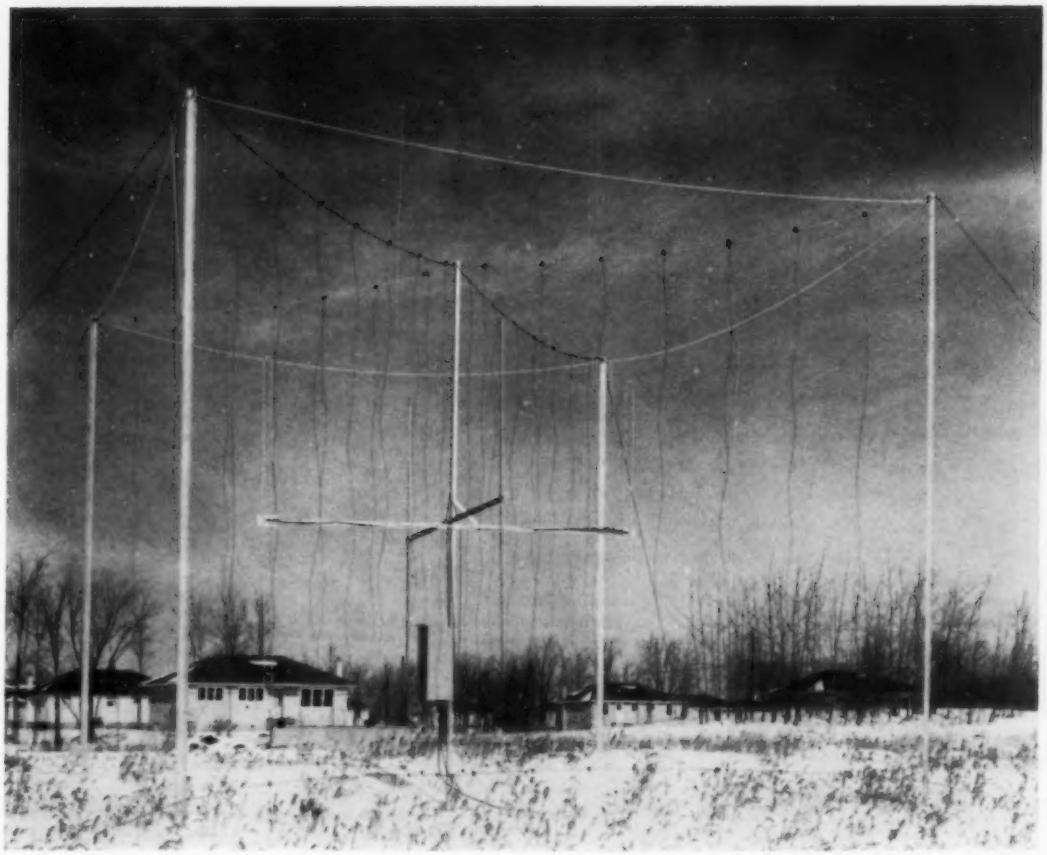
Below:—
Auroral observer's report card, to be used by meteorologists, airline pilots, amateur astronomers and other volunteer groups to record thousands of views of the aurora at hundreds of locations across Canada.





Lower right:—
The principle forms in which the northern lights appear at ground level. These drawings are to serve as models for reporting auroral displays during the I.G.Y. National Research Council Charts

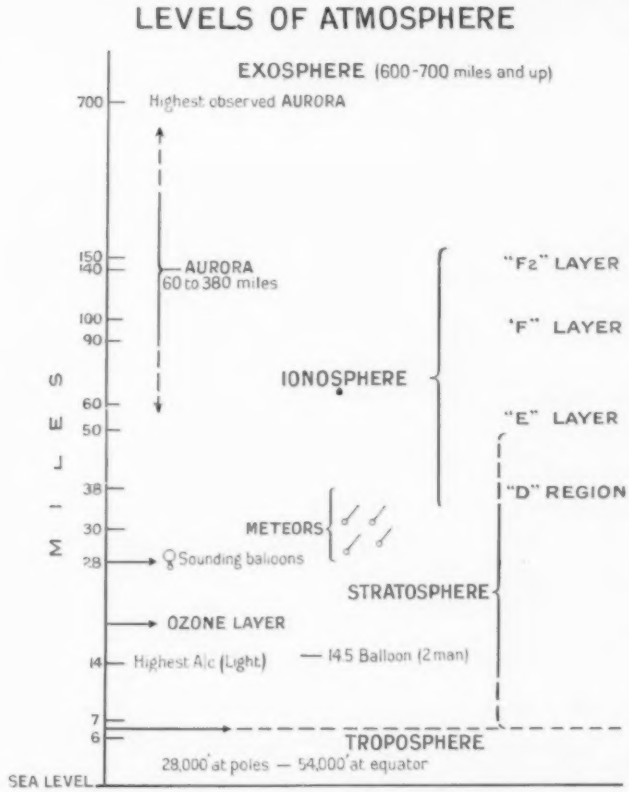
Left:—
The 200-foot tower (right) has been used to mount antennae for auroral radar experiments in the Ottawa area. On the left is a transmitting antenna for I.G.Y. auroral radar studies.
National Research Council



Receiving antenna of the I.G.Y. auroral radar.
National Research Council

pressures, temperatures, humidity, and carbon dioxide content. Some stations will use balloons, aircraft, or rockets to obtain high-altitude information.

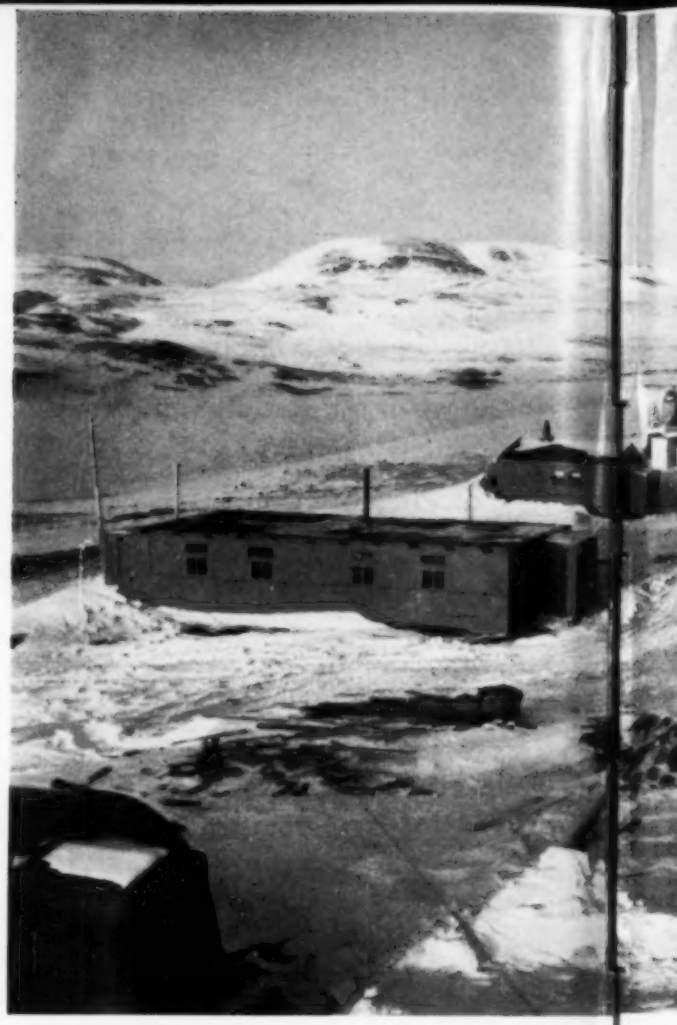
The main objective of the meteorological program is to discover more about the exchange of energy between two distinct levels of the atmosphere, namely the troposphere and the overlying stratosphere, and the transfer of air and moisture between the northern and southern hemispheres. The troposphere, meaning "turbulent area" is the stormy level of the atmosphere where giant winds and cyclones are generated. It ranges in height from ground level up to five miles in cold latitudes and up to nearly ten miles at the equator. About 80 per cent of the earth's atmosphere is packed into the troposphere by the weight of higher levels of air. Through this layer the great winds, known as jet streams, flow constantly at speeds up to 300 miles an hour. More knowledge of the troposphere will mean better weather forecasting. It may also lead to a more systematic use of jet streams in long-distance air travel.



Canadian Participation

Canada already does geophysical research in all fields covered by the I.G.Y. (excluding rocket and satellite techniques). Most of the Canadian stations needed in the far north are already established as a result of scientific development in the Arctic since the last war. For the next two years, however, the activity in most departments will be greatly expanded, especially in auroral studies, meteorology, cosmic rays, the ionosphere, and glaciology.

In all, eighty or ninety stations will be used across Canada, ranging in importance from the Dominion Observatory at Ottawa to isolated semi-automatic instruments. Many of these stations are equipped for several kinds of measurements. For example, at Resolute Bay research covers eight of the I.G.Y. fields; at Fort Churchill six fields, in addition to rocket launchings of the United States program.



The weather station at Alert, northern Ellesmere Island.

Releasing a rawsinonde balloon at Eureka, Ellesmere Island.

The Aurora

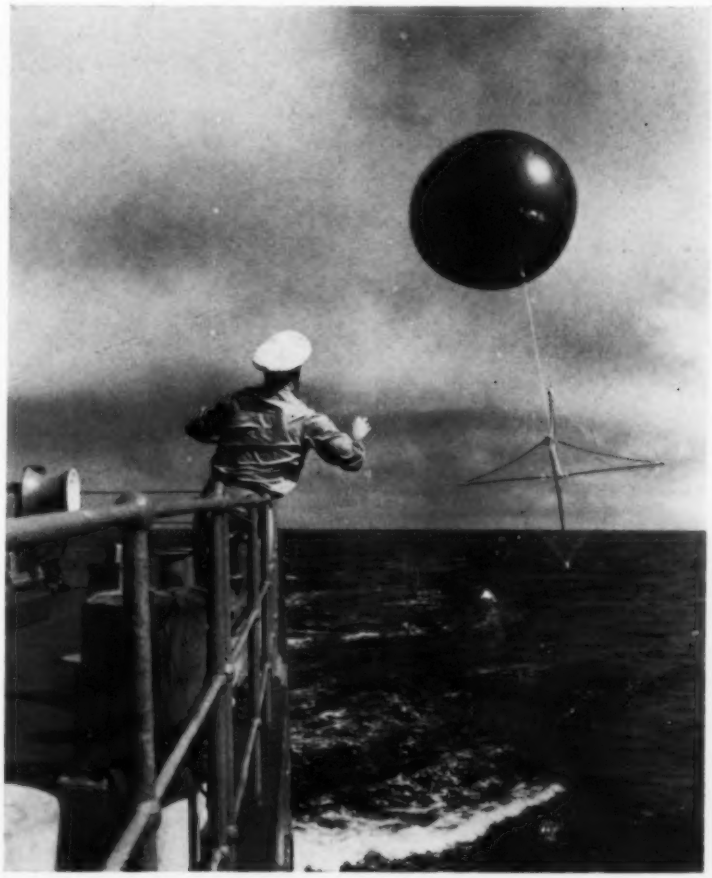
A prominent feature of the Canadian plan are the lines of auroral stations which cut through the main belt of the Northern Lights. The longer auroral line doubles with the Canadian weather stations near the 90° West meridian. Beginning at Alert (about 1,200 miles above the Arctic Circle), the auroral stations include Resolute Bay (700 miles to the south), Baker Lake (700 miles farther south), and Fort Churchill (another 400 miles south).

A second auroral chain in the west begins at Norman Wells (in the latitude of Great Bear Lake), includes Yellowknife (Great Slave Lake), Uranium City (Lake Athabasca), and Meanook (central Alberta), and ends at Victoria, British Columbia.

At several of these stations all-sky cameras will photograph the entire night sky every minute, automatically beginning at nightfall

lesmere Island. Inset: the radiowindsonde room at Alert.

sent up to 100,000 feet for records of temperatures, pressures, humidity and winds. At three stations in the far north special instruments, called Dobson Spectrophotometers, will measure quantities of ozone at high levels. These devices will record and compare the intensities of two different wave-lengths of ultra-violet light from the sun. One of the wave-lengths has the property of being absorbed by ozone; the other comes through to ground level. The difference is an index of ozone concentration. During the polar night similar measurements may be attempted, using the sunlight which is reflected from the moon. The effect of atmospheric ozone on the sun's ultra-violet light is thought to have an important bearing on the heat balance between the earth and the atmosphere.



A balloon carrying aloft a target that can be tracked by radar to plot upper winds.
Department of Transport photographs

and ending at daybreak. Sensitive light recorders will scan a narrow arc of sky in a north-south direction every five minutes of the night, recording various intensities of the aurora. "Patrol spectrographs" will record the wave-lengths of light from the aurora and indicate the gases present; and radar sounding equipment will measure heights of the Northern Lights over wide areas. Close timing of these operations will help scientists to relate one kind of effect with another. In all parts of the country visual observations will be made by volunteers and recorded on cards. The object is to issue periodic synoptic maps of the aurora.

Meteorology

For more complete weather data, which is now collected at forty-five stations in Canada, about ninety stations will be used during the I.G.Y. At a number of these, balloons will be

Cosmic Rays

In cosmic ray research Canada has an important role during the I.G.Y. because of her large land mass in northern latitudes. The incoming cosmic rays are intense near the poles because of the concentration there of the earth's magnetic lines of force. Measurements will be taken continuously at four locations—Resolute Bay, Fort Churchill, Ottawa, and on Sulphur Mountain near Banff.

The origin of these high-energy radiations is a great mystery. They are streams of electrically charged particles, mostly the positive parts of atomic nuclei, which appear to come from outer space, since they impinge upon the earth from all directions, day and night. Their intensity, however, is in part related to the sun's activity, for they are sometimes greatly increased during solar flares.

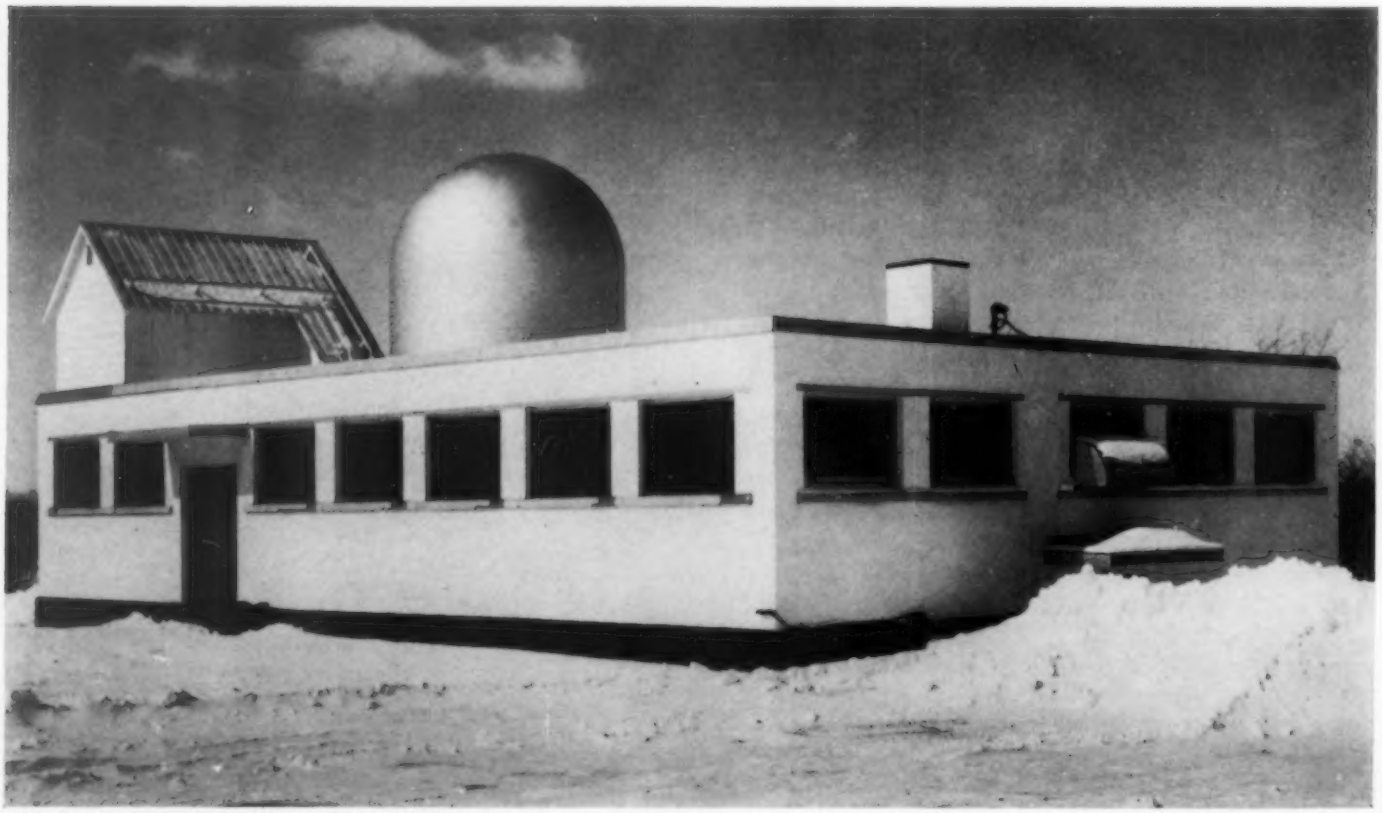
Statistically, one cosmic ray per minute for each square centimeter passes through the human body. But in terms of nuclear radiation this is an extremely light dosage and not injurious to health.

Some cosmic ray particles have enormous energies—far above anything our accelerating machines can produce. They have been recorded at great depths in mines, after passing through many thousands of feet of rock. Again, these great energies are only relative. The particles are fantastically minute and very sparse by comparison with the concentrated energies released in an atomic reactor. The use of cosmic rays as a source of power is therefore not of direct interest.

The lower-energy particles are deflected by the earth's magnetic field and swept towards the north and south poles. Few of these reach the ground. They collide with air molecules and produce secondary particles of many types which are measured at the earth's surface. These provide free and constant material for atomic research. They are the original "atom smashers". The observatory on Sulphur Mountain, at an altitude of 7,500 feet, is to serve both for cosmic ray studies and for research in nuclear physics. It is a joint operation of the National Research Council and Atomic Energy of Canada Limited.

At many locations in the world, including Fort Churchill, rockets will investigate cosmic rays at very high altitudes. Three main problems will be attacked. One is to explain

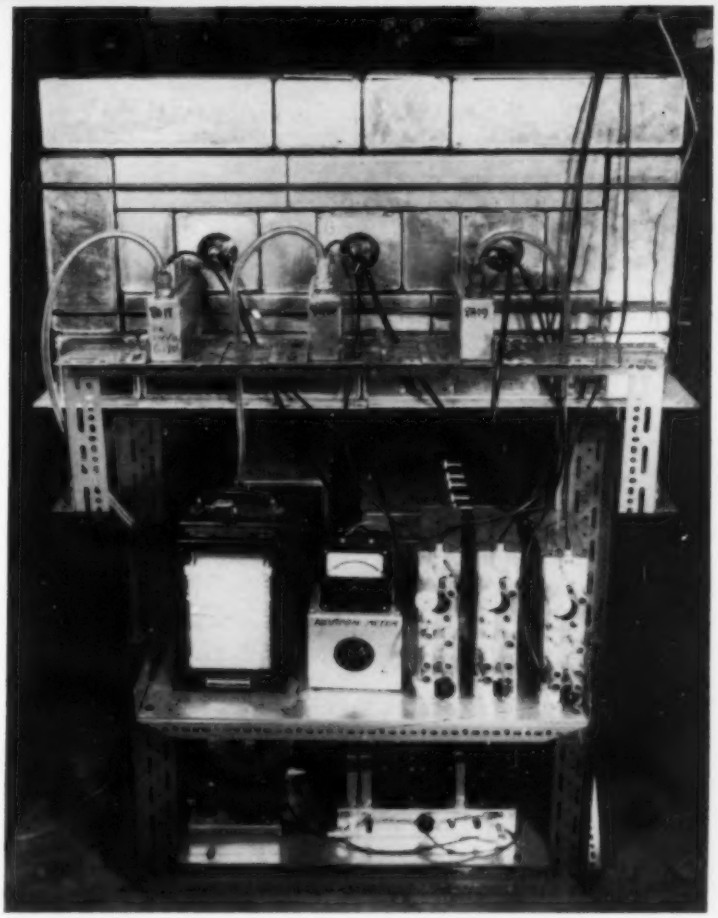
The cosmic ray observatory, National Research Council, Ottawa. Particles from outer space and the sun bombard neutron counters and are recorded by electronic equipment (see photograph opposite page).



the large decrease in cosmic ray intensity during magnetic storms. Another is to account for cosmic ray fluctuations during sun-spot maximum, and the third is to explain their increased intensity during solar flares.

In the study of astronomy cosmic rays are of particular interest. Knowledge of their origin and the cause of their great energies will eventually reveal much about the universe, since these particles are part of the interstellar material—clouds of dust and gas—which is thought to make up nearly half the weight of the total galaxy. Most cosmic ray particles are nuclei of hydrogen atoms, hydrogen being the most abundant element in the universe.

Cosmic ray research is done with cloud chambers, enclosed mixtures of gas and supersaturated water vapour, which show visibly the results of particle collisions. A variant of the cloud chamber is a kind of photographic plate which consists of unusually thick emulsions. Two other devices, based on the principle of the Geiger-Muller counter, are counter telescopes, which record high-energy particles and indicate the angle of their approach, and neutron monitors, which record intensities at the low energy part of the cosmic ray spectrum.



Cosmic ray neutron monitor. The counter tubes are embedded in slabs of lead and wax (top half). Bombarding cosmic ray particles activate the counters; their numbers are recorded by equipment (lower half). National Research Council

The Ionosphere

The ionosphere is important in radio communications. It is an envelope of rarified upper air from fifty to 250 miles above the earth's surface. Gases of the ionosphere are ionized, or partially changed in structure. In its normal state the ionosphere reflects radio waves, and a vast network of radio stations uses these reflecting layers to link every country in the world.

Unfortunately, any unusual activity in the sun may seriously affect radio reception. A sun flare, for example, produces sudden bursts of ultra-violet light which have strong ionizing effects. In less than ten minutes after the flare begins, the ionosphere layers are thickened; they become conductors rather than reflectors of radio waves. This causes complete fade-outs in radio reception. The solar flare may also induce prolonged storms in the ionosphere, magnetic disturbances and auroras. All of this can black out radio communications for days at a time. This interference is a serious problem to populous countries of Europe and North America which lie under the northern auroral zone. Better knowledge of the ionosphere will offer two alternatives: it will indicate the best radio frequencies to be used during times of disturbance and it will suggest other radio channels to by-pass troublesome areas.

Radar is the main tool in ionosphere studies. Vertical "sounding" by radar gives a continuous record of the height of the ionosphere directly overhead. It also indicates optimum broadcast frequencies.

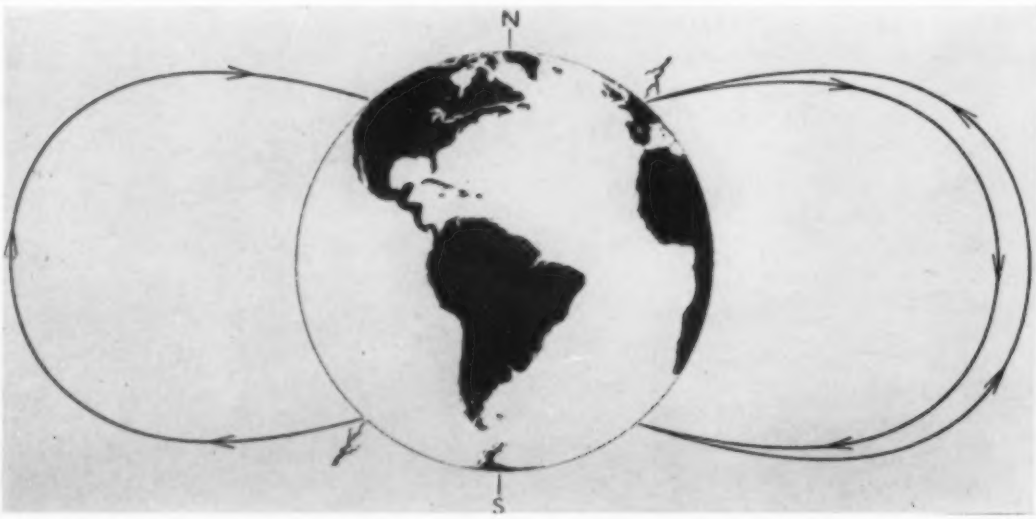
To map broad areas of the ionosphere from a single station, "oblique-incidence" sounding has been developed. A beam of radio energy, either at constant or varying wave-lengths, is swept in wide arcs across the ionosphere. The return echo, known as "back-scatter", gives a pattern for thousands of square miles. An

Chart showing how a transmitter at Yellowknife will beam radio waves obliquely overhead. The reflections from the ionosphere will be received at the five places shown. These studies will show the effects of aurora and other atmospheric disturbances on long-range radio broadcasting. Defence Research Board

alternative system uses twin sending and receiving stations spaced hundreds of miles apart. The echoes which are deflected ahead are known as "forward scatter".

There are now about ninety vertical sounding stations in continuous operation in all countries. Up to fifty new stations will be operated during the I.G.Y. Regular Canadian stations are at Ottawa, Resolute Bay, Baker Lake, Fort Churchill, and Winnipeg; new additions are at Meanook, Yellowknife, and Norman Wells. A backward and forward scatter station is to be set up at Yellowknife, the receiving equipment to be at Sulphur Mountain, Baker Lake, Fort Churchill, Saskatoon, The Pas, and Meanook.

In various parts of Canada research will be done on a special kind of radio wave which occurs naturally in the earth's atmosphere. These waves, known as "whistlers", are known to result from flashes of lightning; they are so low in frequency as to be directly audible



"Whistlers" are radio waves produced by flashes of lightning. They follow the earth's magnetic lines of force (arrows). A long low-pitched "whistler" (right) results from a return trip after reflection from the opposite hemisphere. These natural radio waves are revealing facts about the outer atmosphere, now known to extend at least 7,000 miles from the earth.
Courtesy of *Scientific American*

Henrietta Nesmith Glacier, northern Ellesmere Island, with ice tributary in foreground, Lake Hazen in background. The region is to be investigated by an expedition sponsored by the Defence Research Board. Main objectives: to measure ice movement, to mark the present position of the ice front, and to study thermal conditions in Lake Hazen which is frequently ice-free. The glacier appears to have changed little since 1882. Defence Research Board

through radio-receivers. Whistlers are believed to travel many thousands of miles in outer space before returning to earth, often near the earth's magnetic poles. They may reveal facts about ionization at very high levels, or about the form of the earth's magnetic field.

Meteors

The study of meteors is also linked with ionosphere research. Meteors are small pieces of cosmic material which continually enter the earth's atmosphere and burn themselves out by friction. The larger meteors, which are visible on earth, can be clocked for speed and their exact courses charted by a combination of photography and radar. Radio waves beamed at meteors are reflected from the ionized gases of the meteor trails. Spectrographs will show what the meteors are made of (usually sodium, magnesium, and iron). Two meteor stations operating together can determine the angle of a meteor's flight. Sets of stations on twenty-six mile bases will operate at Ottawa and at Meanook during the I.G.Y.

Glaciology

Canadian glaciologists have three main projects. One is to intensify work on a survey of snow in Canada. Another is to investigate the Salmon Glacier in British Columbia. The third is to study ice-caps on Ellesmere Island.

In the summer of 1956 an advance party of glaciologists visited the Salmon Glacier and

began a study of ice thicknesses (ranging from 2,000 to 2,400 feet), ice movements (about eight inches a day), underlying rock features, and ancient moraines. One purpose of the Salmon Glacier survey was to train men and test equipment for the Ellesmere expedition.

The Ellesmere Island expedition will record information on ice movement, glacial erosion, climatic effects, and associated plant and animal life. One of the climatic puzzles of the area is why Lake Hazen on Ellesmere Island should be free of ice when salt water forty miles away is frozen.

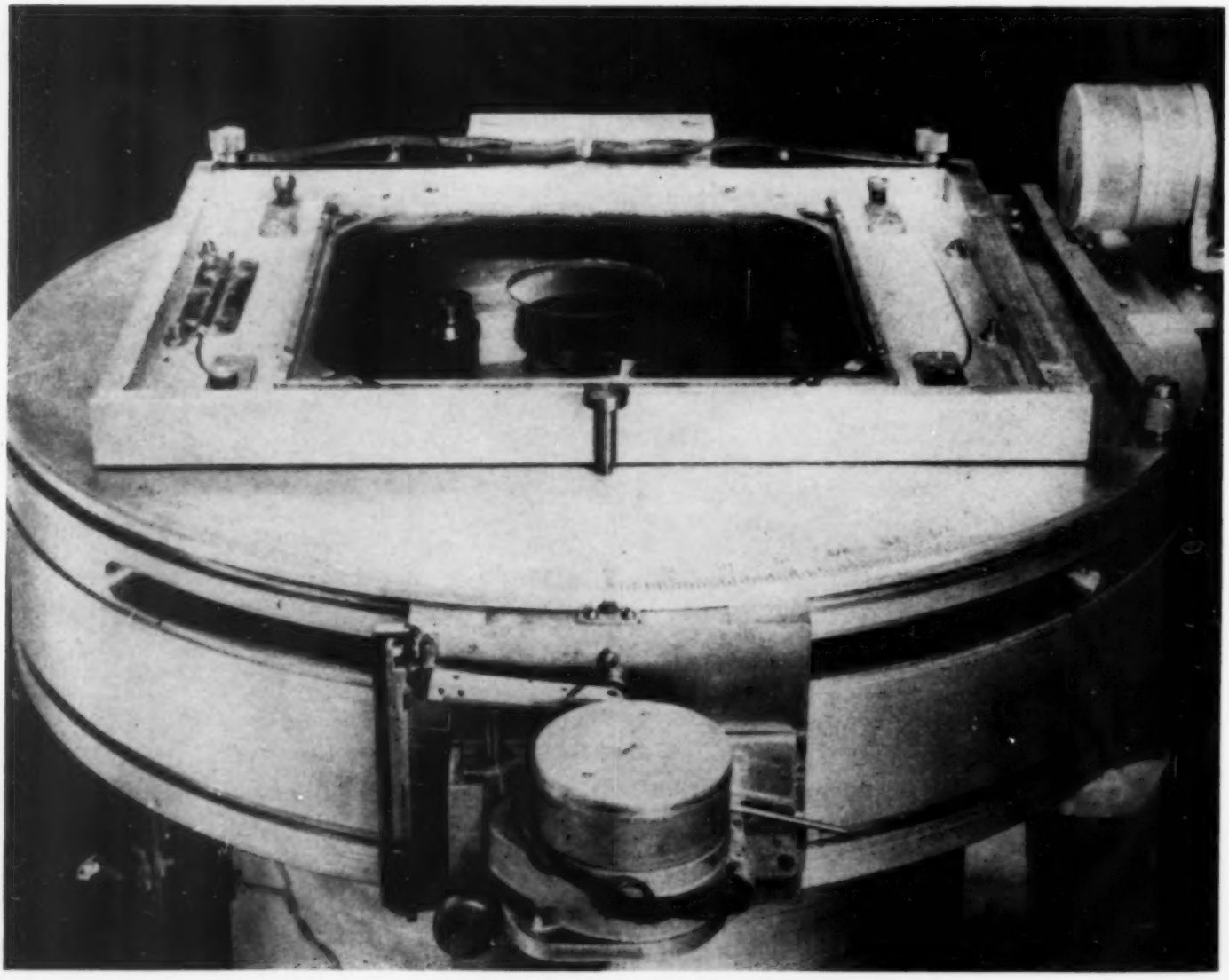
These glacial studies will be related to large programs of glaciology which United States parties are conducting on the Greenland ice-caps, the Juneau Ice Field in Alaska, and on the Columbia Ice Field and Saskatchewan Glacier in western Canada.

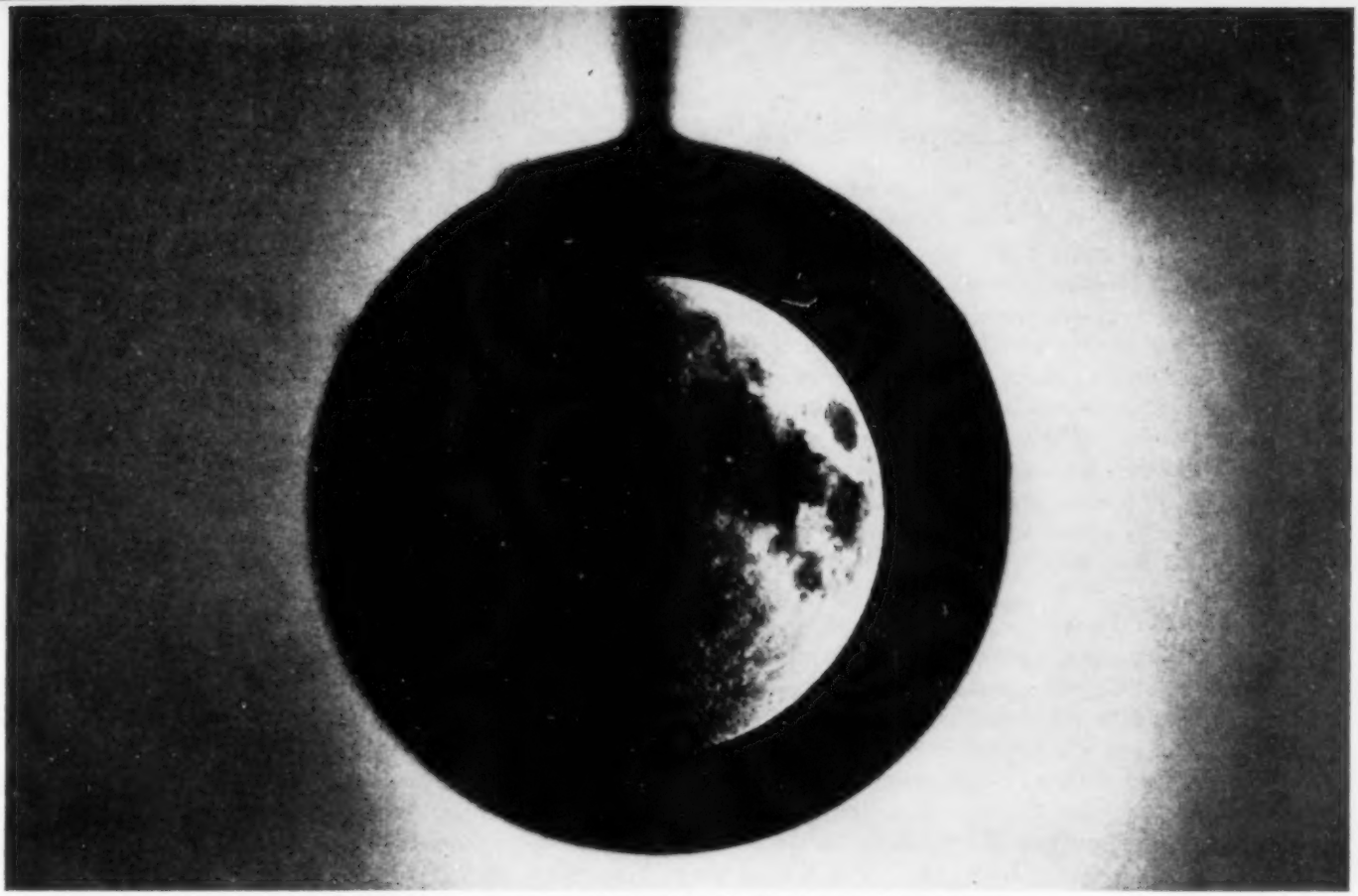
Geomagnetism

Today there are nearly 100 magnetic observatories around the world. With the aid of ships and aircraft these stations compile magnetic charts used in navigation. The main source of the earth's magnetism is internal. This part of the field is subject to slow variations which are regular in pattern but the cause of which is unknown. A small part of the earth's magnetism has an external source which is believed to result from electric currents induced in the ionosphere by the sun's rays. This external field has daily and hourly variations as the earth revolves. The probable paths of the electro-currents have been deduced in theory and to some extent verified by evidence obtained from rockets.

In addition to these regular variations, there are rapid and unpredictable fluctuations of the

The Markowitz Moon Camera provides a new observation technique for determining such facts as the earth's speed of rotation and the size and shape of the earth. It obtains a sharp image of the moon against the background of stars, which permits precise measurements. Geodetic Service, Dominion Observatory





A photograph of the moon as obtained by the Markowitz Moon Camera.
Geodetic Service, Dominion Observatory

earth's magnetism which occur during sun flares. Probably the sudden jump in ultra-violet radiation during the flare quickly raises the conductivity of the ionosphere, causing the electro-currents to increase. A resulting kick or "crochet" is delivered to the sensitive needles of magnetic observatories. More violent and prolonged magnetic storms often disturb navigational and surveying techniques for considerable periods of time.

The I.G.Y. will plot a world picture of magnetic effects and relate these to the sun's rotation, to solar flares and other earthly phenomena. The nature and cause of the electro-currents may be definitely established.

In Canada magnetic stations will operate in established locations at Agincourt, Ottawa, Meanook, Baker Lake, Fort Churchill and Resolute Bay, with new stations at Yellowknife and Victoria.

Seismology

Scientists consider the earth to be in an intermediate state between a liquid and a solid. At its centre it is still liquid. The cool outer crust is relatively thin and therefore subject to great stresses both from the cooling process and from movement of the liquid core. This liquid is affected by the same kind of gravitational pull from the sun and moon as the surface waters of the earth, and a phenomenon resembling tides is constantly at work in the earth's interior.

These forces result in mountain-building, earthquakes, volcanoes and tidal waves. The earth is always in a state of mild shakes and tremors; parts of the crust are moving imperceptibly; there may be gradual drifts in the position of continents, or minor shifts which affect islands, coastlines, and national boundaries; there is a steady series of minor earthquakes, most of them only discernible to the sensitive instruments of the seismologists.

From the study of the earth's crust, serious earthquakes and tidal waves may some day be predicted. The I.G.Y. program in seismology will extend to remote oceanic islands, to the Antarctic, and to other untested areas in order

to fill in gaps in the network of "listening" stations. New seismographs will be in use which record long-wave earth tremors even up to a duration of seven minutes. These tremors indicate elastic properties of the earth to great depths. Much interest will centre in the Antarctic, where some of the heaviest earthquakes have occurred. In Canada the current program of seismology, which is conducted at twelve stations, will be continued in a normal way. A most important station for the I.G.Y. in completing the world network is the one at Resolute Bay.

Gravity

If the earth were a perfect sphere, if it were solid throughout and uniform in composition, then the gravitational pull all over its surface would be equal and constant. However, both in shape and density the earth has variations. It is flattened at the poles; its heaviest fluid material at the centre undergoes tidal deformation which is transferred in some degree to the elastic outer crust. In the crust itself heavier materials, such as ore bodies, are massed among lighter rocks. There are irregularities due to mountains and valleys both on land and beneath the sea.

Fixing the position of points on the earth's surface, which is essential to mapping and geodetic surveying, is done by reference to the stars. The method is extremely accurate, provided the measurements can be referred to a true perpendicular. The perpendicular is obtained by a plumb-bob or similar device which depends on gravity. Even very slight local variations in gravity will cause significant error.

A detailed knowledge of the earth's gravitational field is also important in determining the exact shape of the earth. Gravity measurements have other more practical uses in the exploration for oil and minerals.

The I.G.Y. studies will measure variations in gravity more accurately and more completely than has been possible heretofore. Extra-sensitive gravimeters will record variations caused by the "earth tide"—the slight bulge of the earth caused by the sun's gravitational pull. Extremely accurate pendulums will be used for measurements along three meridians from the Arctic to the Antarctic. The pendulums will also serve to calibrate more mobile types of instruments for measurements over close networks radiating from the primary stations.

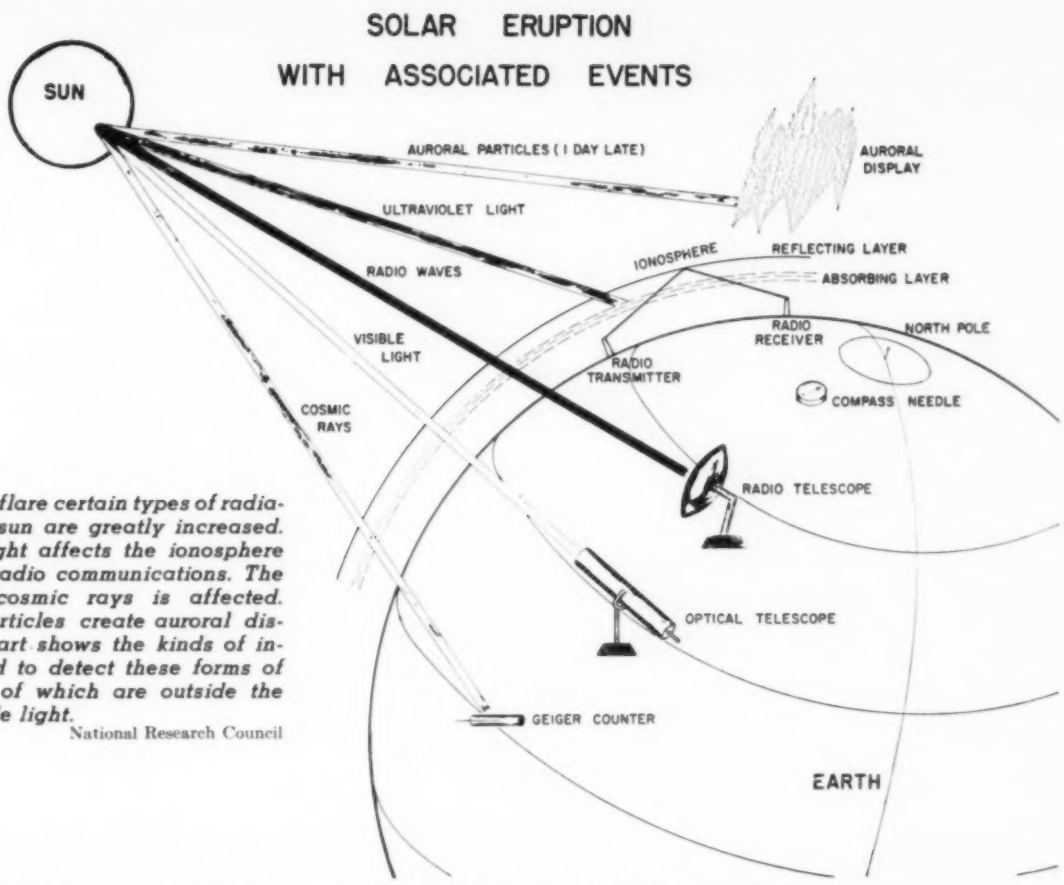
In Canada a primary east-west chain of pendulum stations will operate at Gander, Knob Lake, Seven Islands, Winnipeg, Edmonton, and Vancouver. Other pendulums will be used at Fort Churchill and Resolute Bay, and gravimeter measurements will be taken at about 400 locations east of Hudson Bay. Farther north, previously-obtained data will be confirmed. The observations in the Arctic are important in determining the earth's flattening toward the North Pole. United States scientists in the Arctic will work from ice-floe stations as they drift about in the ocean, and their observations will be related to results obtained at land stations in Alaska and Greenland.

In the Antarctic a special purpose of gravity studies is to support glacial and seismic determinations of ice thicknesses and underlying rock masses across the continent.

The most imaginative of all the gravity studies will be done with the earth satellites. As a satellite circles the earth, any variation in the earth's gravitational pull will cause a shift in its orbit. The variation will be measured by the tracking instruments and related to the satellite's position with respect to the earth. This study will help to confirm other information about the true shape of the earth.

Longitudes and Latitudes

The world program in longitudes and latitudes is based on several problems resembling those of the gravity studies but employing quite different techniques. For example, an attempt will be made to determine the exact distance between continents, which is now known only approximately. At a future time it will be learned to what extent, if any, the continents are shifting. The measurements will be made by Markowitz Moon Cameras. With these cameras, the position of the moon relative to the stars is obtained with high precision. The same technique, coupled with accurate timing with quartz-crystal clocks, will



During a solar flare certain types of radiation from the sun are greatly increased. Ultra-violet light affects the ionosphere and disrupts radio communications. The intensity of cosmic rays is affected. Streams of particles create auroral displays. The chart shows the kinds of instruments used to detect these forms of radiation, all of which are outside the range of visible light.

National Research Council

give extremely fine measurements of the earth's speed of rotation. This speed is known to vary slightly, both in a regular and predictable way and also in an irregular fashion which is not understood.

Moon cameras will help to solve another problem: to obtain exact distances from many points on the earth's surface to the earth's centre. The precise size and shape of the earth may then be defined.

No special Canadian project in geodesy is planned for the I.G.Y., but a moon camera will continue in operation at Ottawa as part of a continuing world study in longitudes and latitudes.

Oceanography

The oceans cover the three-quarters of the earth's surface about which least is known. During the I.G.Y. the oceans will be studied at two levels—at the surface and at great depths. The problem is two-fold. The first is to understand oscillations in sea levels which are independent of tides. These may be caused by storms, the earth's rotation, or the great oceanic wind systems. Moreover, seasonal variations up to six feet occur in the spring in each hemisphere. Whether these changes are caused by melting snow and ice or by a mass flow across the equator is not known.

The second problem is to define the movement of deep-sea water. In a project called Operation Deep Current, specially-equipped vessels will study the water moving northward from the Antarctic along the bottoms of the Atlantic and Pacific Oceans, the equatorial currents, and all levels of the mixing waters at the equator.

Canada will do tide studies at St. Andrews, New Brunswick, at Nanaimo, British Columbia, and in the Arctic Ocean. Along with other countries, she will also assist United States ships in the study of deep ocean currents.

Knowledge of deep ocean mixing, about which little is known today, might be applied in three directions. First, it might supply another key to meteorological techniques, since ocean waters are undoubtedly a major weather factor. Second, the dispersal pattern of the deep currents might solve future prob-

lems of atomic waste disposal; radio-active substances could be sunk in deep ocean holes, if it were known what the effects would be. Finally, man may turn more seriously to the oceans for supplies of food and other resources. What he may learn now about the movement of marine waters will help him to assess the oceans as a potential source of wealth.

Solar Activity

During the I.G.Y. a constant watch will be kept on the sun. The sun plays an obvious part in the phenomena of day and night, the seasons, and the climatic zones. It also performs at times a positive but more obscure role in earthly events. Unusual solar activity, through its effects on the atmosphere and the earth's magnetism, interferes with normal weather factors, disrupts radar and electrical communications of all kinds, and even disturbs navigational techniques. But in each case the chain of events is not clearly understood.

Seventy I.G.Y. stations spaced around the world will study the sun's corona, and record solar flares and prominences. The watch will continue every minute of the entire eighteen-month period, during which the sun will approach the peak of its eleven-year sun-spot cycle.

Solar flares are of prime interest. Always associated with sun-spots, they are more frequent and more intense at sun-spot maximum. Then as many as ten flares may occur within twenty-four hours. These may be only short bursts of light lasting for a few minutes. But a few are likely to be more pronounced. An intense solar flare is said to be the most dynamic sight in the whole heavens. A part of the sun's atmosphere, perhaps 1,000 million square miles in extent (about the size of a large sun-spot) suddenly blazes up to ten times its normal brilliance, throwing out white-hot streamers of gaseous material, spewing jets and filaments to heights of 300,000 miles or more. The phenomenon increases for a few minutes, then slowly subsides in an hour or so.

During such a flare surge, great quantities of energy are propelled from the sun in the form of both waves and particles. The wave bands, including visible light, ultra-violet light, and radio energy, reach the earth first, in about eight and one-third minutes, all travelling at the speed of light. The particles, on the other hand, vary in speed and produce delayed effects lasting for twenty-four hours or more. Results of a solar flare may persist in the earth's atmosphere for several days.

At Ottawa three Federal Government agencies will assist in the world-wide "solar patrol". Flares will be recorded photographically with special filter equipment. Measurements of solar noise (radio emission) will be taken every day at various wave-lengths. For reference purposes, two of these frequencies will be the same as those used in radio sounding of the ionosphere. Information of two kinds will be sent to the I.G.Y. warning service in Washington, D.C., — daily noise level from the whole solar disc, and the times and intensities of noise from flares.

Radioactivity

One further study may be added to the I.G.Y. list. This is an examination of radioactivity in the atmosphere, which in recent years has been increased by the testing of atomic and hydrogen weapons. Details of the plan, if it is to be adopted, are not yet available.

World Days

At critical times during the I.G.Y. special care and timing will be essential. To ensure this, a Calendar of World Days has been agreed upon. The world days are of four kinds. "Regular World Days" coincide with phases of the moon and periods of heavy meteor showers. "Alerts" are warnings a few days in advance of probable solar flares or magnetic disturbances. "Special World Intervals" are short-notice alerts preceding these events. "World Meteorological Intervals" are ten-day periods four times a year during the equinoxes and the solstices. Most of the rocket launchings will take place during these intervals.

A radio warning service will feed the alerts into a world system of radio and telegraphic networks. In the western hemisphere weekly summaries of data which have been sent to a tabulating centre at Washington will be reissued by airmail to all stations which request them.

Opposite:—
Recording solar noise, National Research Council Observatory, Goth Hill, Ontario. In the foreground is a radio-telescope of 10-foot diameter which automatically follows the sun and records intensity of total radio emissions. In the background is the 150-foot linear receiver which scans the sun's disc in narrow strips as the earth rotates, thus locating spots of unusual activity. National Research Council

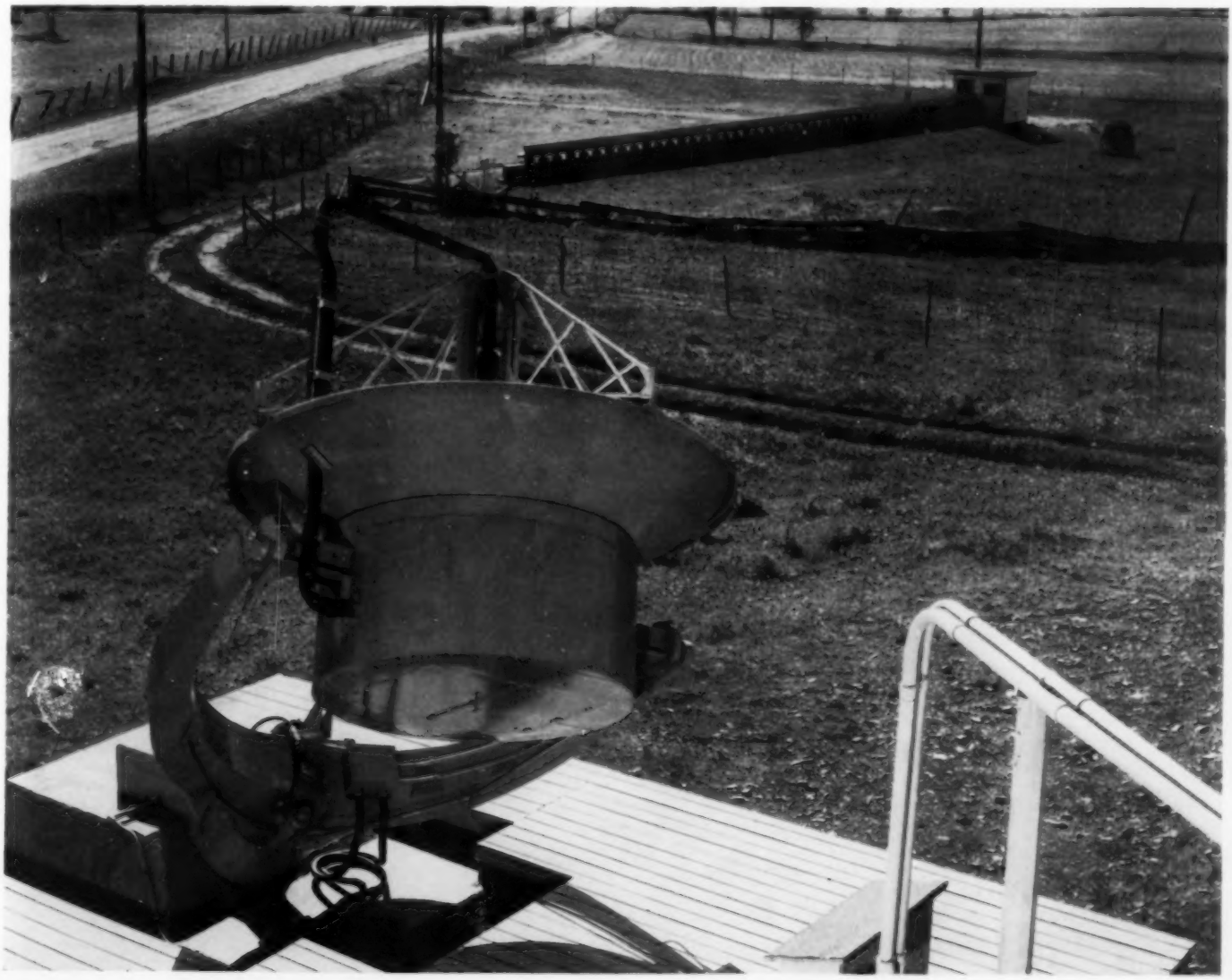
Analysis of Data

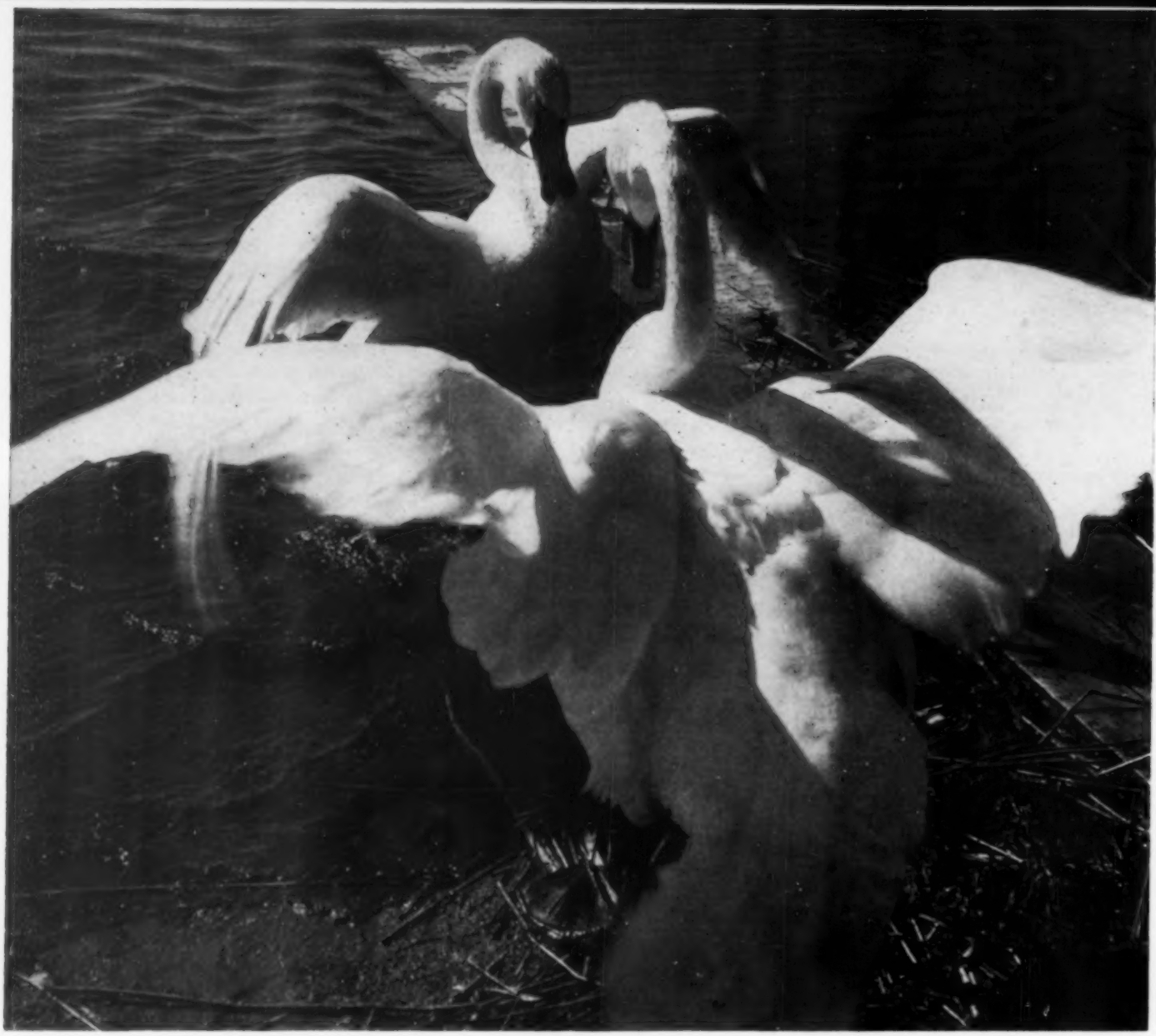
Publication of reports of the I.G.Y. will require several years. Canadian results will be analysed first in Canada, then submitted to various world centres, according to disciplines. There will also be area centres, for example, for the western hemisphere, for Europe, and for Soviet Russia.

The final report of the 1932-3 Polar Year was issued only in 1951, but in this case the work of analysis was interrupted by the Second World War. Scientists hope to see the report of the I.G.Y., which may run to many volumes, published by 1965. But results of the studies will be prepared in interim form long before then. Indeed, from the day the program begins, much useful information will be available, and already significant data is coming from the preliminary research.

Geophysical Assembly

At the outset of the I.G.Y., Canadian interest will be heightened by the Eleventh General Assembly of the International Union of Geodesy and Geophysics (I.U.G.G.) which will be held at the University of Toronto in September, 1957. Up to 1,500 experts in the earth sciences from fifty or more countries will gather for two weeks, mainly to review the initial progress of the I.G.Y., and set the final objectives as the program gets under way. For the first time since plans were drafted at Brussels in 1953, the full scope of the varied undertakings will be surveyed by those who are to conduct much of the work. Large contingents are expected from the United States, Britain, the Commonwealth, and Soviet Russia. In charge of arrangements is Professor J. T. Wilson, vice-president of the I.U.G.G.





The courtship display of a pair of trumpeter swans. The birds undulate and beat wings in unison.

Waterfowl Research at Delta, Manitoba

by LYN HARRINGTON

Photographs by RICHARD HARRINGTON

DROUGHT on the western plains, and the consequent decline in the waterfowl population, brought into being the Delta Waterfowl Research Station at the foot of Lake Manitoba.

Today, the wet cycle of the past few years presents opposite problems. The staff and visiting biologists now study flood damage to waterfowl feed, destruction of nests due to high water, increased muskrat population in the marshes, and grain depredations by ducks.

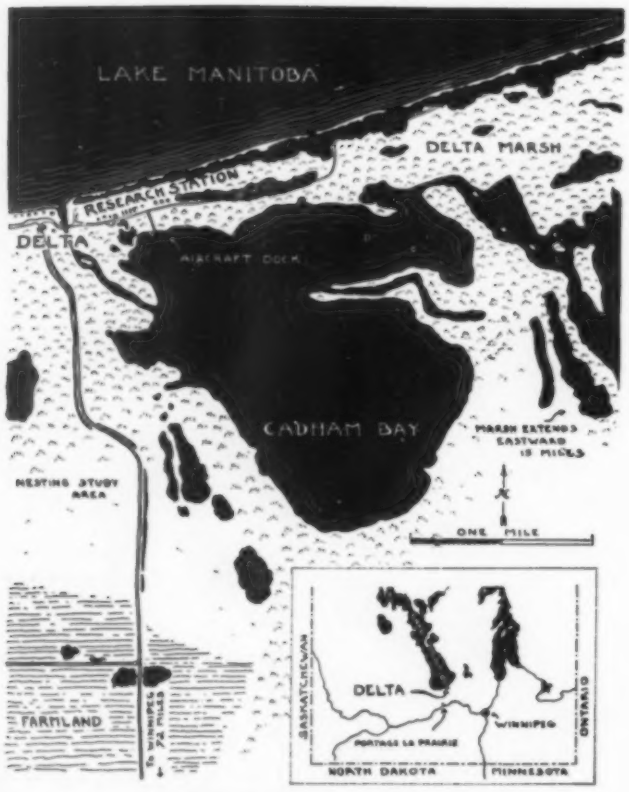
An observation tower covered with reeds overlooks marsh, station pond and netted flight pen.

The immense Delta Marsh, one of the largest on the Canadian prairies, stretches over nearly sixty square miles north of Portage la Prairie. The marsh has been celebrated amongst wildfowlers since prehistoric times. Plains Indians and later homesteaders there gained a supply of ducks and geese to eke out their winter stores. Today's sportsmen are out in their blinds before daybreak to take their quota of the migratory flocks.

For Delta is a crossroads of the duck world, on the Mississippi Flyway, that great aerial migration boulevard. A slender wooded ridge forms a barrier between the marsh and Lake Manitoba. South, east and west are grain fields. With such diverse habitats, Delta provides an ideal location for research into wildfowl behaviour.

Canada geese, swans and many species of ducks are in the station's study-flock.

High water surrounds the former hunting lodge now transformed into a students' dormitory.



THE DELTA STATION AREA

The function of the station is "to study ducks at their source, to serve as a clearing-house for information, and direct such knowledge to useful ends in field biology."

Sixteen species of wild ducks breed at Delta, twelve of them common. It is home for half the year to many ducks, for nesting, rearing their young, and the "vacation" period before migration. In addition, the marsh has many migrants on their way to and from northern nesting grounds, and residents such as coots, terns, gulls of several species, swans and pelicans. The ridge attracts innumerable songbirds, swallows, red-winged and yellow-headed blackbirds, and a remarkable concentration of yellow warblers.

Delta Waterfowl Research Station was established in 1938, with H. Albert Hochbaum as director. The station is the outgrowth of a wild duck hatchery set up by James Ford Bell of Minneapolis. Mr. Bell has had a shooting lodge on the ridge for many years, where King George V went hunting in 1901, while Duke of York.

During the twenties, Mr. Bell realized that the duck population was shrinking. He determined to do what he could to help by collecting wild eggs, hatching them, and releasing the young over the marsh. He released thousands more birds than he shot. But still the duck count dropped.

Mr. Bell recognized that rehabilitation of the ducks required over-all scientific study, so he turned the buildings over to the American Wildfowl Institute. Research has been carried on for nearly twenty years at Delta. Station facilities have grown, and the program is now permanently sponsored by the North American Wildlife Foundation of Washington, D.C., with seven Canadians on the board of directors.

About three square miles, including the village of Delta with its summer cottages and year-round fisherfolk population, form a game preserve. Some 36,000 acres of marsh are open to public shooting.

The Research Station itself includes a few cottages on the sandy ridge, a lodge which serves as dormitory for students, three former mink sheds transformed into offices and library, a good-sized hatchery and small laboratory. A

netted flight-pen contains birds under observation, and a pinioned flock sails the station pond. A netted decoy pipe opens at one corner of the pond, where ducks are lured into a trap for banding or study.

At Delta, the behaviour of wild birds can be contrasted with that of the station's study-flock of pinioned birds. The effect of incubator and hatchery can be compared with the survival rate of birds growing up on the wild marsh outside.

The effects of farming pressure on the waterfowl population have been studied, in co-operation with farmers around the edge of Delta Marsh. Depredations of mink, crows and skunks have been calculated; nest losses due to stubble or bush fires. Indeed, the entire effect of man on the marsh ecology can be gauged. Since wild ducks are a "harvestable" resource, hunters co-operate by allowing their take to be weighed, aged, and sexed, so that the effect of hunting pressure may be estimated effectively.

Delta Waterfowl Research Station has a small permanent staff, and a large number of visiting biologists who undertake special projects during the season of open water. The station serves as a research centre for such men, providing opportunity for both intensive and extensive work. Here graduate students in wildlife management may work in the field under such leaders, and develop their own projects on which to base a thesis for a Master's degree or doctorate.

Over fifty technical dissertations have been published as a result of studies at Delta. Several are full-length books, including two by Director Hochbaum, *Canvasback on a Prairie Marsh*, and *Travels and Traditions of Waterfowl*, and the prize-winning *Prairie Ducks*, by Dr. Lyle Sowls. Several nature films have been shot at Delta for theatre and television distribution, and a considerable number of canvases have been painted there. Canadian Broadcasting Corporation technicians have recorded bird calls for half-hour documentaries, repeated by popular request.

Most of the students come from American universities, but Canadian participation is increasing. One graduate in wildlife management

In a blind overlooking the marsh, a New Zealand student records waterfowl behaviour.

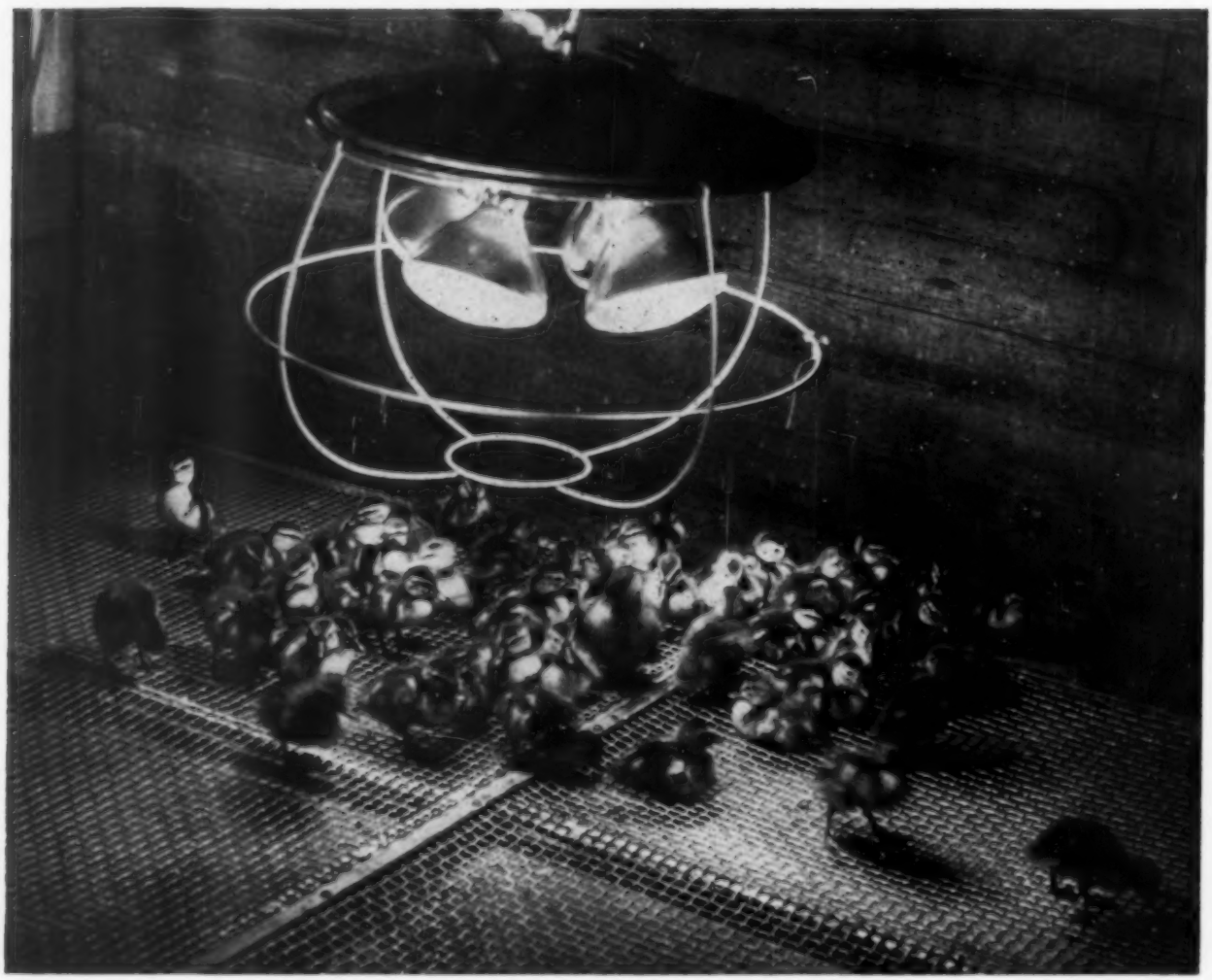
came from New Zealand, and completed a three-year study of the Canada goose before returning to his native land. Another student came from England, after work under Peter Scott at the Severn Waterfowl Trust, and returned later. He is Dr. Frank McKinney, now Assistant Director of the Delta Waterfowl Research Station.

Birds have been trapped for study by ingenious devices, including the duck decoy tunnel. Cannon-propelled nets have trapped the nesting hen out in the marsh. Watchers in blinds have spied on territorial defence and brood-raising, while movie cameras recorded visual proof of the surprising courtship displays of waterfowl.

Students and visiting biologists at Delta took blood smears of ducks to detect endoparasites in the bloodstream, and determine how they affect the health of the bird. X-rays revealed how much lead the average duck bore in its body as a result of poor shooting. The effect of radar on migrating waterfoul was studied, and it was found that flocks broke formation when in the field of the radar beam.

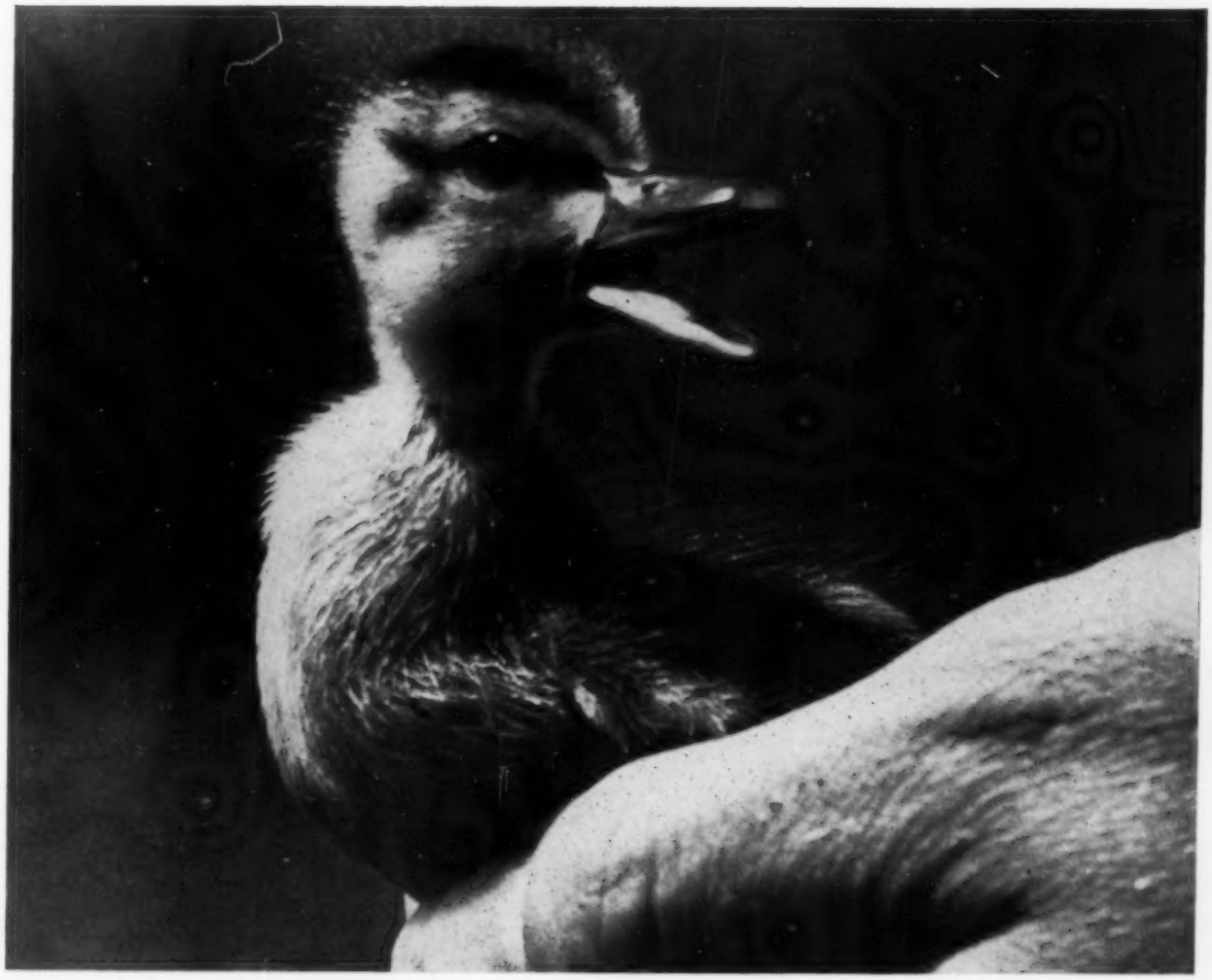
Peter Ward, the hatchery superintendent, sprays wild duck eggs in the incubator. Every egg is carefully annotated.

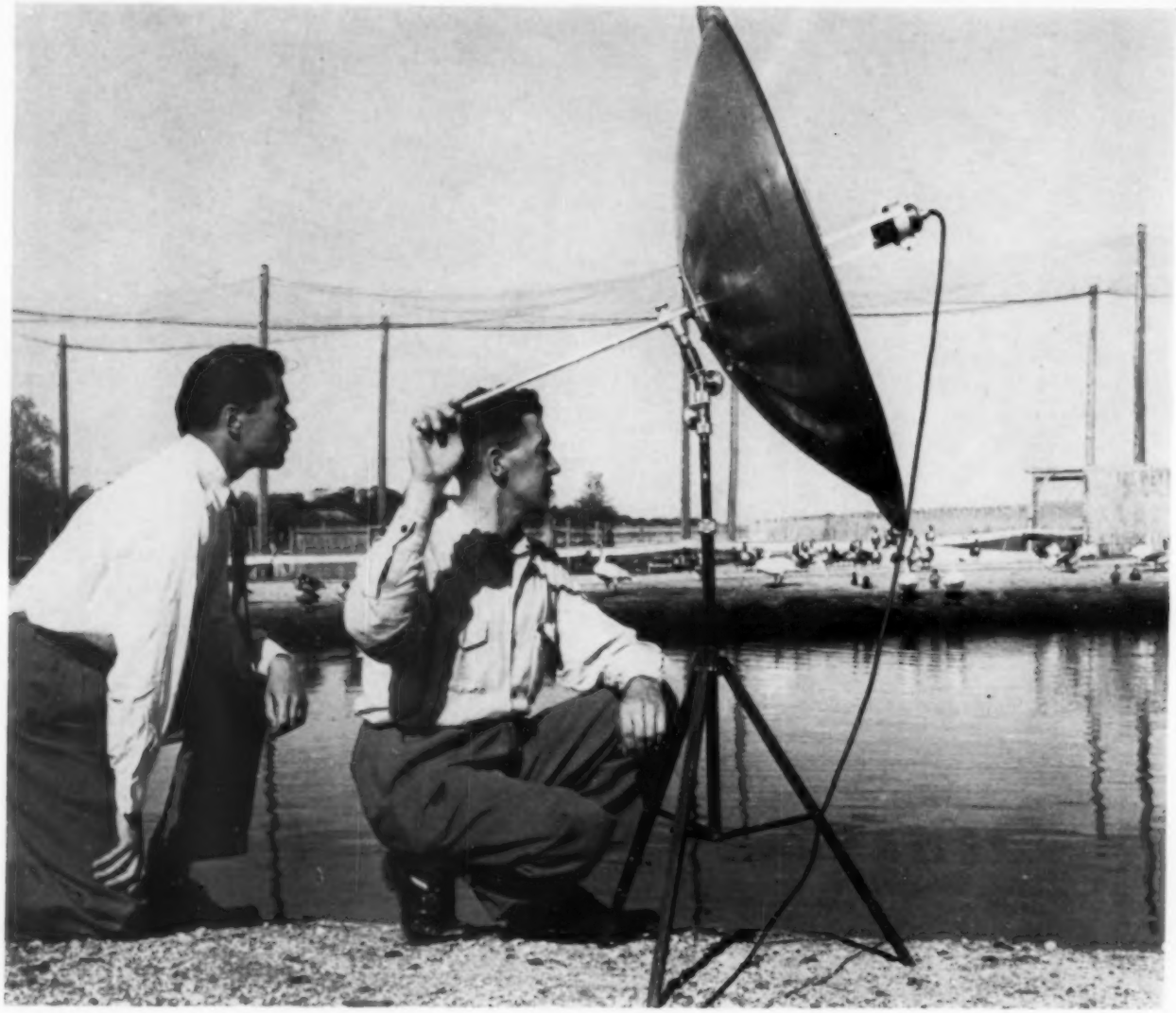
Day-old mallard and canvasback ducklings under heat lamps in the brooder-house of the hatchery.



Girl students are rare at Delta. Here one of them is weighing a day-old ruddy duckling, which has its head marked for identification.

This canvasback duckling proved a ready collaborator with its friend the scientist.





Using a parabolic reflector, Canadian Broadcasting Corporation technicians record bird calls for a broadcast.

Irish-born Dr. Frank McKinney, a graduate of Oxford University, is the Assistant Director at Delta.

One student spent two summers investigating the redhead's parasitic habit of laying its eggs in neighbours' nests for others to hatch.

The station has hatched about one thousand birds a year, under permit. Nests are located by observation, by use of hunting dogs which point the nesting hen. The eggs are transferred to a down-lined collecting box, carefully numbered, and noted as to area, species and date. Records show that while females start life in the same proportion as drakes, far fewer hens are found in adult flocks, probably due to predators while on the nest.

In the hatchery, the ducklings range in age from those under warm infra-red lamps at one end of the brooder-house, to older birds being hardened for the open air. Every bird handled at Delta Research Station bears a numbered aluminum band. Nearly 30,000 birds have been banded as part of the intricate bird-count which is sent to Washington. Birds artificially reared are every bit as healthy as those on the marsh outside. But they are evidently less wary, and a greater proportion of their bands are turned in by hunters.

One biology professor from Cornell University studied day-old ducklings to ascertain their inherent responses. He discovered that they would follow the first voice they heard, whether that of the scientist, a dog, or their own mother.

Eggs have been inoculated with vegetable dye to colour the down, so that the ducklings may be studied individually, and in the group. The dye lasts only until the down is replaced by feathers. Mature birds have been wing-painted for ready identification, with quick-drying paint that does not affect flight, and which vanishes in the next moult.

The findings of the Research Station have sometimes affected legislation. For example, studies of the redhead proved that these birds had scarcely learned to fly before the shooting season opened. They fell easy victims to hunters' guns. As a result, Delta Marsh was declared a nursery marsh, and the shooting date there is later than on other Manitoba marshes.

A student in the "pot-hole" area of the province brought to light a fact not widely realized. Ducks may gather in multitudes in a marsh in fall, congregating in preparation for migration. It was therefore believed that large marshes meant a large duck population. He found, however, that for nesting purposes, ducks prefer the small sloughs where they can more easily defend their territorial rights. For hunters and naturalists this is a strong argument against draining sloughs.

The staff at the Research Station is attempting, successfully, to re-establish Canada geese on the marsh. These were once familiar there, until hunting pressure grew too great. Now the Canadas are coming back, partly due to the captive flock, most of which are released each autumn, and some of which return the next spring. Other small flocks are being raised in extension projects out from Delta. It is hoped the young of captive birds will return to their birthplaces.

On the whole, the staff makes no attempt to change the conditions under which waterfowl live. The station is there to study existing circumstances, and publish its findings. Some projects have inadvertently altered conditions.

A student experiments with compass and fishing-line, to determine whether ducks always take off into the sun, as is claimed.

Mallards are quick to desert their nests. A mallard hen is caught in a nest-trap, as part of a study of re-nesting and deserting habits.

A Dutch assistant at Delta introduced this ancient technique for building shelters for mallards, complete with ramps.

When a canal was dredged to drain an interior marsh, the ducks quickly appropriated the dykes thrown up, and this inaugurated a study of "edge manipulation".

Students fan out from Delta on related projects, such as the studies in the pot-hole country near Minnedosa, Manitoba. One student, now with the Canadian Wildlife Service, conducted a survey of the twelve sloughs within a square mile. He found that the intrusion of man and his machines does not necessarily drive out the waterfowl, as sportsmen claimed, and that the ducks build in the farmyard itself, if not disturbed.

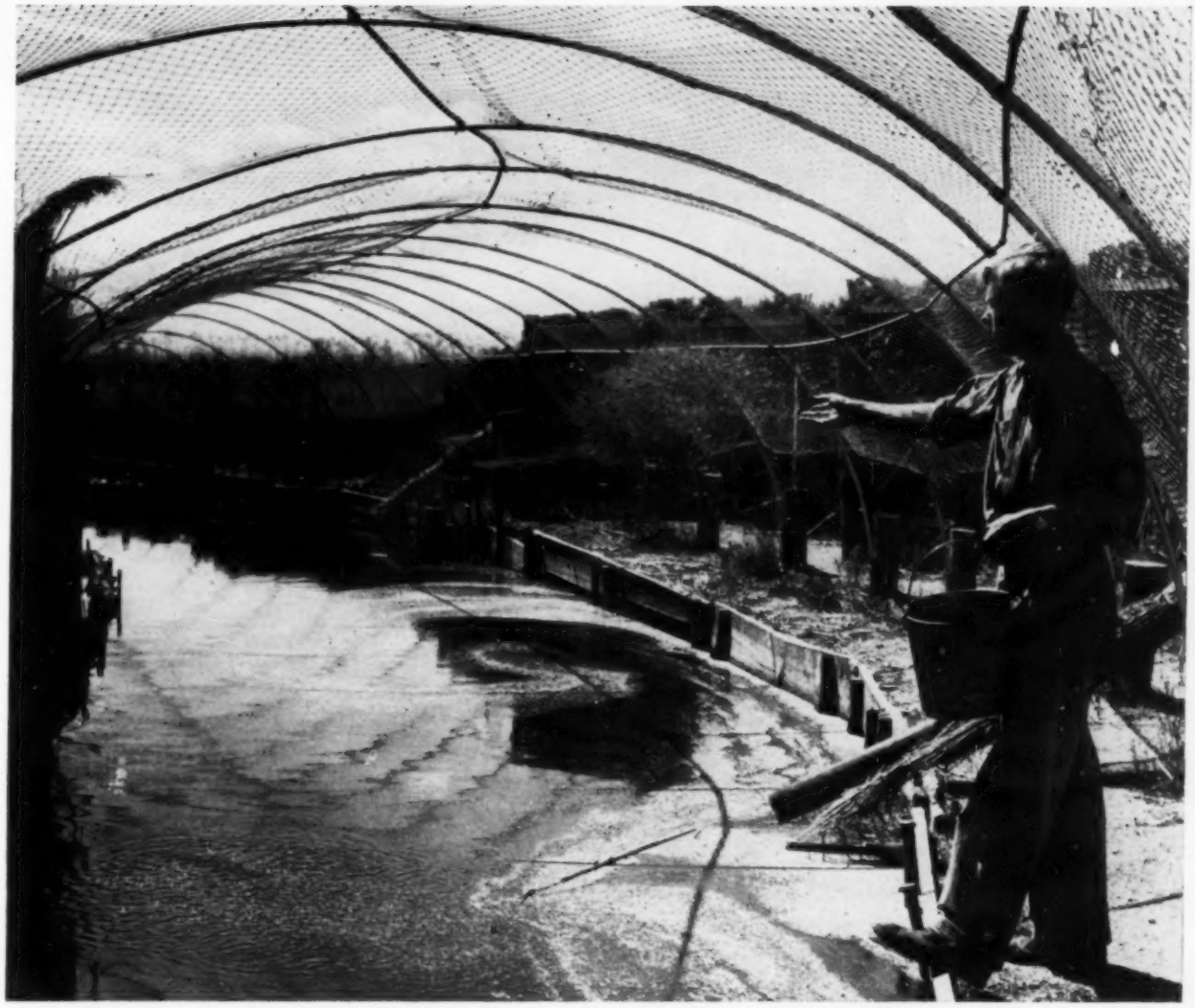
Farmers who enjoy a fall shoot admit to mixed feelings regarding the increase of waterfowl. In rainy summers a few have lost heavily to ducks, which trample the swathed grain, destroying far more than they eat.

Such depredations are a serious matter, one that has merited the attention received from federal and provincial authorities, as well as from scientists. Biologists from Delta have scanned the skies, counted the ducks descending upon grain fields, compiled statistics, and tried out various devices to scare away the birds. It appears that the only real control, short of wholesale slaughter, is to furnish the fields with movable scaring devices, including blank shot.

Another project out from Delta is at sprawling Whitewater Lake, in the south-western corner of Manitoba, where students have been working on botulism in waterfowl. Some students are carrying on their work in study areas of Ducks Unlimited, in Alberta.

Experiments have shown that marshes can be re-seeded with waterfowl. Eggs transferred from Delta to various marshes have renewed the populations. Recent experiments proved that young ducklings could be transferred to a marsh, and their urge to return to the place of juvenile experience brought a few back to their new home, rather than their birthplace. Such information will be valuable in future attempts to repopulate marshes.

Drought in the thirties occasioned great worry on the part of nature-lovers, as well as sportsmen, when the duck population fell so low. At that time, biologists concentrated on



The decoy-pipe—a netted cornucopia up which ducks are lured into a trap, by means of grain scattered on the water.

the drying-up of marshes where ducks had congregated for ages past.

Now the situation is completely reversed. Phragmites and cat-tails have altered in predominance with the high water of recent years. This calls for different research, since vegetation has a decided effect on nesting. Shorelines have changed, forcing waterfowl to hunt new nesting grounds. Deepening of the water is killing pondweed, a favourite duck food, with the result that canvasbacks have had to find new locations. Study of the pondweed is high on the list of future research projects at Delta Waterfowl Research Station.

A biologist paints identifying colours on a mallard's wings, so that the bird can easily be traced.

His Excellency The Right Honourable Vincent Massey, C.H., Governor-General of Canada and Honorary Patron of the Society, chats with two of the Society's officers before the Annual Meeting of the Society. Left to right: Major-General H. A. Young, president; His Excellency; General A. G. L. McNaughton, vice-president. Newton

Everyman His Own Geographer *

by His Excellency The Right Honourable Vincent Massey, C.H.

It is with much pleasure that I find myself with you tonight. Let me assure you that I do not say this merely as a concession to the ordinary forms of courtesy. I really am glad to be able to foregather with the members of a Society for whose work I have long had a very deep admiration. There is no need for me to emphasize the important contribution which you make to Canadian life.

Puis-je dire un mot dans leur propre langue à nos concitoyens d'expression française. Leur présence ici nous rappelle que les premiers géographes canadiens étaient de langue française. Leurs exploits, tels que nous les relisons aujourd'hui avec fierté sont une source d'inspiration pour leurs successeurs et tous ceux qui s'intéressent à l'histoire du Canada.

I am glad to be here for certain good reasons.

*This address was given by His Excellency at the twenty-eighth Annual General Meeting of the Society in the Lecture Hall of the National Museum of Canada, Ottawa, on 21 February 1957. It was recorded by the Canadian Broadcasting Corporation and was broadcast over the national network later the same evening.

First, I find myself in the company of a number of old personal friends whom I see in this room. Secondly, although I hold no degree in geography, and have written no learned work, and have made no great discovery, I think I can claim with pride to be one of the largest living consumers of Canadian geography and, may I say, one of the keenest students of Canadian geography. My studies are carried on in very modern fashion by what the educationists call the direct, or project, method. I can now, with confidence, claim from you the award for a Canadian Amateur Geographer Class I, for there is perhaps not very much of Canada's geography that I have not been privileged to see.

Moreover, still in the modern manner, I have learned the easy way. I can proclaim to the skeptical young inmates of modern classrooms that learning geography can be fun. I have, indeed, found it so. But I do not have to convince you that geography can be fun. This study must hold for you the same fascination which it has always had for explorers and men of science, who have drawn aside the veil of the unknown to uncover the secrets of their environment.

It is trite to say that the study of geography in Canada has special importance and interest because there is still so much to uncover. When I think of the vast field of enquiry still open to you, I am reminded of the story of a Negro woman in the deep south. When asked if she had any corn pone she replied:—

> "Honey chile, corn pone is what we ain't got nothing' else but."

Not many generations ago, we could have almost said the same of our geography. We had little else. But over the years our land, with its mystery and its riches, has prompted enquiry and adventure, given us wealth and shaped our thinking—created a nation in what were once thought to be empty wastes.

There is no need for me, addressing this audience, to talk about the long line of brave and able men who have wrested from the northern half of our continent so many of its secrets. But are our boys and girls familiar enough with the tale—our Canadian tale? The men who came in the early years from France, from England, from Scotland, from Scandinavia, and later from the older parts of our own country—the procession is unending and still continues— belong to a story of exploration which should prove absorbing to every schoolboy and moving to his elders. Francis Drake once asked Queen Elizabeth for her support in an enterprise which he had conceived. She asked if there were any risk and if he thought the undertaking would be successful. He replied:—

> "Madam, success is not certain, for the wings of a man's life are plumed with the feathers of death."

This is true of countless endeavours in our vast land.

Recently I have been reading *The Private Journal* of Captain Lyon of the Royal Navy, which was published in 1824. He spent, you will recall, two and a half years in the Arctic in his little ship *H.M.S. Hecla*. His purpose was to map the northern coast of the continent. He possessed no academic degrees, but he was a geographer in the fullest sense of the word—not only did he chart the region but he studied the rocks, the vegetation, the climate and the fauna. He gave an account of the natives and the way of life demanded by their environment. This is only one example of the countless enterprises from the beginning to the present day, in which endurance and courage and determination gave us knowledge of our own great north. Last spring when I flew over the North Pole in an aircraft of the R.C.A.F. I found it an experience as humbling as it was fascinating. Here I was travelling in comfort, over a region in which men had suffered great hardships and had often spent years facing overwhelming and sometimes fatal hazards in their searches.

The primary functions of your Society are related to the geography of Canada, but it has not been conceived on narrow lines—you are concerned with geographical studies in general. Scholars of many lands are ready to defend—if defence is necessary—such researches as their chosen pursuit. The French, renowned for their brilliant work in this field, are among the most enthusiastic. "Geography", we learn from one of their scholars, "comprehends all the sciences, opens all

vistas, embraces all human knowledge." And, this loyal Frenchman adds, "We place the University of France on the summit of a pyramid with the word 'geography', towards which all human knowledge tends..." Perhaps, as Canadian geographers, we can throw aside our cold—may I say our deliberate?—moderation, and place this subject (I need not say that I name no Canadian university!) at the summit of all learning?

But why—we may ask—why must the enthusiastic geographer be so exclusive in his worship? The answer, I believe, is not far to seek, although here I must defer to my colleagues who, if their "projects" have perhaps been less extensive than mine, have given—if I may employ an understatement—more profound attention to the scholarly aspects of the study. Why must the modern geographer proclaim his faith with so much fanfare? His studies have always been of first importance. They deal with the whole physical environment of modern man—its impact on his mind and character. It is the vast home where he spends his life. It is concerned with what this home does to him, what he does, what he can do, what he should do, with it. Man has never been able to dissociate himself from the facts which, to so large an extent, govern his life.

All this is true. It is also true, as geographers know very well, that their subject hitherto has largely been the handmaid, one might almost say the slave, of other studies or pursuits. It is hard to understand why the establishment of Chairs of Geography in modern universities—which gave it is full status in the academic field—took place only recently. Geography in its own right has too often been relegated to the very junior classroom. There, in a rather charming way, it reflects the recent or even the not so recent, history of the community. Think of those limitless lists of capes and bays which we wrestled with years ago in school; what are they but the dessicated fragments of that living knowledge which meant not merely a livelihood but life itself to our forefathers, the great seafarers of the western world? Similarly, the depressing catalogues of county towns, which used to afflict our infant minds, doubtless reflected the local preoccupations of those who guided our early educational steps, or their sense of the cost and the arduous efforts of their grandparents who created these communities.

But having served as the medium for this and other curious lore, geography, after the elementary years, disappeared from formal studies. It was still there on the higher levels, more or less, but it had been captured by history, economics, literature, art and even philosophy; by geology, biology, chemistry and physics; and in the world of affairs by politics, military strategy, navigation, and in modern times by all forms of commercial enterprise. These varied creatures have battened on geography's helpless form. No wonder that those who have recognized and resuscitated her now, with perhaps a slight excess of enthusiasm, do her honour as the source of all knowledge.

We may not go quite so far, but we should recognize geography as at once a fascinating popular pursuit and a great academic discipline. Your Society plays an admirable part in bringing such studies to the attention of the Canadian people in every aspect. As an association of scholars, you give to geography its true place. You also give pleasure to the amateur. Through your journal you cater to many tastes, and you stimulate a wide variety of articles from the strictly scientific to the popular and entertaining. Your universal appeal is splendidly reinforced by the generous use of photographs of distinction. Last, but not least, you endeavour to keep in touch with geographers everywhere through the book reviews of the magazine. I cannot overstate my sense of the importance of such service. Nothing, I believe, will contribute so much to Canadian cultural development as a knowledge of what is being done in Canada and abroad in any particular field of interest.

It is, may I suggest, on occasions such as this, appropriate to ask ourselves again exactly what the study of geography means and should mean to the individual and to society. That it can mean a quite astonishing and absorbing variety of things every reader of your journal knows.

One can probably think of geography in two

ways—one can regard it as both an art and a science. This does not precisely express my meaning, but for the moment it will serve.

We might think of geography first as an art. It begins with experience, man's experience of his own physical invironment. He translates this experience in all sorts of ways. He employs it for the furtherance of his practical designs. But it is geography too that helps him to realize the ultimate futility of designs which are merely "practical". They should draw him on to deeper understanding and contemplation. I could, I am sure, illustrate all of these geographical practices from the whole of history, if I knew the whole of history. I could certainly illustrate them from the limited historical knowledge at my disposal.

Obviously man cannot live a moment on earth without employing his knowledge of geography. There have been certain epochs in history when the geographers ought to have been—but generally were not—the first citizens of any country. I am thinking, for example, of the great surge of energy in Europe which resulted in the occupation and development of the American continents. Europeans were deserting their piecemeal overland trade with the Orient and on the high seas were striving to reach their objective directly. It was a time of great practical designs; it was also an age of great grographers of all kinds, practical and theoretical. Men like Magellan and Vasco da Gama, Columbus, and Cabot, Cartier and Drake come to mind. Behind them, however, stand those whose bold ideas and patient researches provided the foundation for the work of the men of action; giants like Copernicus and Galileo, and men like Dr. Dee, the remarkable English geographer—part-mathematician, part-astrologer—who helped to persuade the Elizabethan navigators that the world was waiting for them to open.

This reminds us of one of geography's most publicized triumphs—the development of the study of "geopolitics". It was, as you know better than I, this enquiry which, early in this century, began to turn men's minds from the dogma of sea power and the pre-eminence of sea-going people, to the modern view that (given our communications—railway, the motor car, the aeroplane) the solid land mass has the greatest potential for world domination. This theory, developed and made popular by MacKinder, (I remember how exciting I found his book when I read it years ago), has received astounding and even frightening, confirmation in our day. It is only another illustration of the immense sweep—as well as the painstaking detail—involved in the work of the geographer. It is only one more illustration of the need for attracting to this study not only able technicians and scientists, but also profound philosophic minds.

On our own continent, the practical necessity for fish and furs, and the spiritual urge to save men's souls and bodies led a handful of men in a few decades to open the water gates to what is now the centre of power in the western world. It is interesting and cheering to note that Champlain, the first of this heroic group, not only was, but called himself, a geographer. Today, as we have often been reminded, we are completing the opening up of this immense area. The St. Lawrence Seaway will be a great achievement in modern engineering—and we should be proud that the major share of it is a Canadian responsibility—but new though this development is, it is, of course, but the final exploitation of an ancient water route—a geographical feature as old as North America itself.

It has often been said that Canada is a compromise between history and geography—with the natural geographical lines running north and south—and our links with the old world in history and tradition lying east and west. The Seaway represents both history and geography and will, of course, make a profound impact on Canadian life in the intangible as well as in the economic sphere.

Here is an example of man's ability to influence his environment. The geographer, as his plans are put into effect, is continually finding new ways for us to exploit our physical surroundings in Canada not only in the regions which still can be called the frontier but also in those parts which have been settled for many generations. There is unbroken continuity between Champlain and his astrolabe and the prospector with his geiger counter.

We are still in the full flush of exploration and discovery; it is, perhaps, the most exciting period of an exciting history.

Great geographers for long have of course been concerned with the effect of environment on the mind and temperament of man; "human geography", such studies are rightly called. I find it fascinating to speculate on what will be, over the generations or centuries, the impact on the people who live in our country of our climate and physical setting. Perhaps your researches will throw light on this. Will our surroundings give us national traits and qualities which are peculiar to ourselves? How far has this process already gone? Environment, we can agree, shapes and influences man, just as man moulds and changes his environment. Our people come from all parts of the world, but I think that even now our physical surroundings have given us qualities of our own. In many ways they are unique. We are a people of the north like many others, but Canada is the only large northern country in the world without a sub-tropical south. (We won't discuss the immediate influence of southern climates on some of our compatriots now temporarily absent from us, as this might smack of envy!)

It would be a commonplace to say, especially to this gathering, that the greatest geographical influence in Canada is derived from the Precambrian Shield. Lying across the country and dividing it, it has governed our politics and Constitution because it has shaped our economic foundations. How right it is that our national capital should stand on the border between the two geographical Canadas—our great fertile plain and our vast area of rock and lake and forest. Only a few miles from here—just behind Hull—we can stand on the plain and see, a few hundred yards away, the outcrop of the Shield itself.

There are regions in Canada which leave vividly their stamp on the people who inhabit them. I was conscious of this not long ago in the Arctic when I flew across the tree line which runs from Churchill to Aklavik. On one side lies the tundra—the barrens—on the other the forests, and the natives of these two areas, so much alike, are yet so varied in such matters as their means of transport, and their diet, as to have developed, over a long period, marked differences in their modes of life.

As I have tried to suggest, there is much more to geography broadly conceived than practical undertakings, just as there is to life itself. I have already mentioned the illustrations in your journal, some of them reproductions of paintings, others photographs, notable for their variety, for their precision, sometimes for their striking beauty. Your pictures carry on beyond the functions of the engineer and the economist to the realm of the artist and the poet—and why not? Poets from time immemorial have practised the art of the geographer with power and precision. So have painters. It was Canadian poets who first showed us our own country; and it was Canadian painters who, through their interpretation, can be said to have found Canada's northland and who are still opening it before our eyes. The discoveries of writers and artists are peculiar to them. They see, and convey, a sense of the unseeable in nature and in man. When I spoke of the influence of environment on people, I was thinking not only of physical effect for natural beauty plays its part. Our artists, as I have suggested, have given us vivid records of that. We have only to remember the influence of the grim beauty of Algoma on our first native school of painters. But the splendours of nature affect those who perhaps are unconscious of the process. I heard in Newfoundland the story of a brakeman in the caboose of a freight train who was overheard to say, standing by the door as dawn was breaking, and gazing at the receding countryside:

> "Night's candles have been put out one by one."

We have all been moved by the peculiar charms of our country which take so many forms. I have seen much of this for the first time within the past year: the opal lights on the great mountains of Ellesmere Island; the savage grandeur of the Fraser Canyon near Pavilion Mountain; the dark forests of Sitka spruce in the Queen Charlotte Islands; the varied panorama of the Gaspé Coast; the sombre beauty of the Saguenay; the black and

white pattern of the Mackenzie Delta in winter seen from the air. These are some of the glories of our land—there is natural beauty everywhere for those who have eyes to see, and consciously or otherwise it must affect us profoundly. In a recent Canadian novel the author, Ethel Wilson, speaks of the impressions of a traveller crossing Canada traversing

> "...the country with its sleeping past, its awakened future, the gradual progress of discovery and habitation, the extravagant forests, prairies, lakes, and mountains, the great beauty, the isolated and sometimes collapsed shack that speaks of human effort and departure, the sudden appearance of a city in all that solitude (like an explosion)—the land enchants and speaks to him [the traveller]. The land is full of question. The journey disturbs and exhilarates."

I am expecting every moment to be called to order not so much for getting away from my subject as for abusing it. I shall no doubt be told that I have divided geography between the scientist and the historian, the poet and the painter, leaving the geographer, as always, in the cold. You will say to yourselves, "that is what happens when we ask a layman to address us!" But I am not forgetting the position of geography. I am reminding you, perhaps in too many words, of what we all know, that every man should be his own geographer, and that a knowledge of geography is basic to most human arts. We must all be geographers if we are to live intelligently in this world, just as we must all be historians if we are to live acceptably in society. Geography and history are universal arts. When they cease to be so, civilization decays.

But geography, like history, is a science as well as an art. The more crowded the house, the more careful must be the planning and organization of space. The more crowded the world, the greater the need for precise knowledge of every part, and of every aspect of every part. Moreover, the more complex the relations between countries (or provinces, or towns) the more important it is that we should have a clear and comparative knowledge of them. To collect such varied data, it is true, has become the task of the biologist, the mineralogist, climatologist, agronomist, ecologist, demographer and so on—I groan under the weight of language! Geography, as always, is parcelled out among the specialists. But this does not mean that the geographer works for the specialists. Rather they work for him. It is his task to assemble all facts and to see the total human environment; to exhibit man's home to him clearly, precisely, objectively, not from the point of view of the carpenter, mason, plumber or painter, but from the point of view of the man who lives there. Modern geography is, and must be, an exact science.

But like all great sciences philosophically approached, it must be numbered among the humanities. It is, as I have already ventured to assert, an art. Its character as a study, derives not only from the fact that it shows the physical world to man; it also places before him in peculiarly sharp and striking form, human problems requiring the keenest analysis, and the most careful judgment of value. It is this responsibility which has transformed modern geography. Until the last century the "environmentalists" had it all their own way. Montesquieu, with his implication that government was the product of climate, was one of the most famous of a numerous band. The modern geographer, with his eye on the past and future, as well as the present, shows the absurdity of assuming man as passively receiving impressions. Men, of course, as we know, influence their environment; not only are they influenced by it. Modern man, from Copernicus with his eyes on the stars, to the *habitant* with his mission to "*faire la terre*", has created (and has been created by) the modern world. Here then we have a subject in great need of precise scientific analysis and sound philosophic judgment. I mean the delicate and shifting question of the influences operating between men and their earthly dwelling place.

How are these ends to be attained, these tasks to be accomplished? By continuing such good work as you and others in the same field are doing. I would not understate past achievements, but I would remind you that in all really great tasks—and yours is a great task—there are limitless possibilities.

The village of Boscastle. A young Cornishman secures a heap of lobster pots.

The Duchy of Cornwall

by S. GORDON JOSEPH

Photographs by the author except where credited.

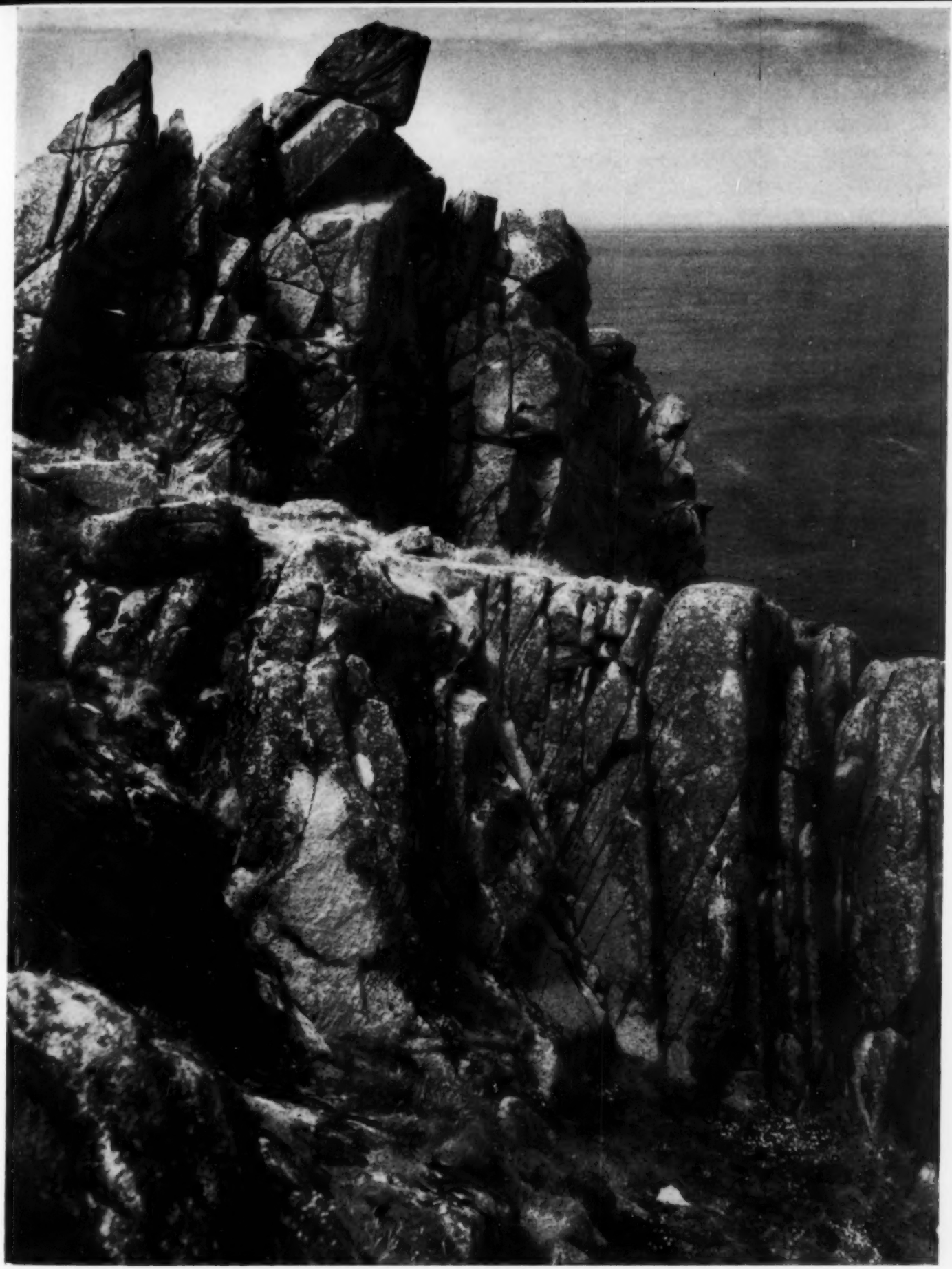
CORNWALL is one of the most ancient parts of Britain. It is a land one day massive and brooding under heavy black rain-laden skies and the next basking peacefully under a mild sun. It is a land of expansive open moors over which the raging Atlantic gales tear unhindered towards the east, and of narrow river valleys so thickly forested that only occasional patches of skylight find their way through the tangle of leaves and branches to the banks and streams below. Its comparatively small area contains a remarkable variety of terrain, vegetation, industry and occupation.

Behind it lie these sober geological facts. Cornwall is composed of alternations of sedimentary and igneous rocks whose combinations supply the contrast to the scene. Its oldest rocks, probably of Precambrian age, are the metamorphic schists and gneisses of the Lizard promontory. Next in time come the pre-Devonian and Devonian which form the chief part of the region, followed by some Carboniferous rocks, slates and grits in the east.

About this period, intrusions of igneous rocks from below cooled slowly to form the granite hills of the west. In Cornwall these are the moors of Bodmin, Hensbarrow, the Penryn district and the St. Just promontory. The Scilly Isles farther west were formed in the same way. Such are the main features of this geologically complex area, but there are others which to some degree affect the scene and the life of its inhabitants.

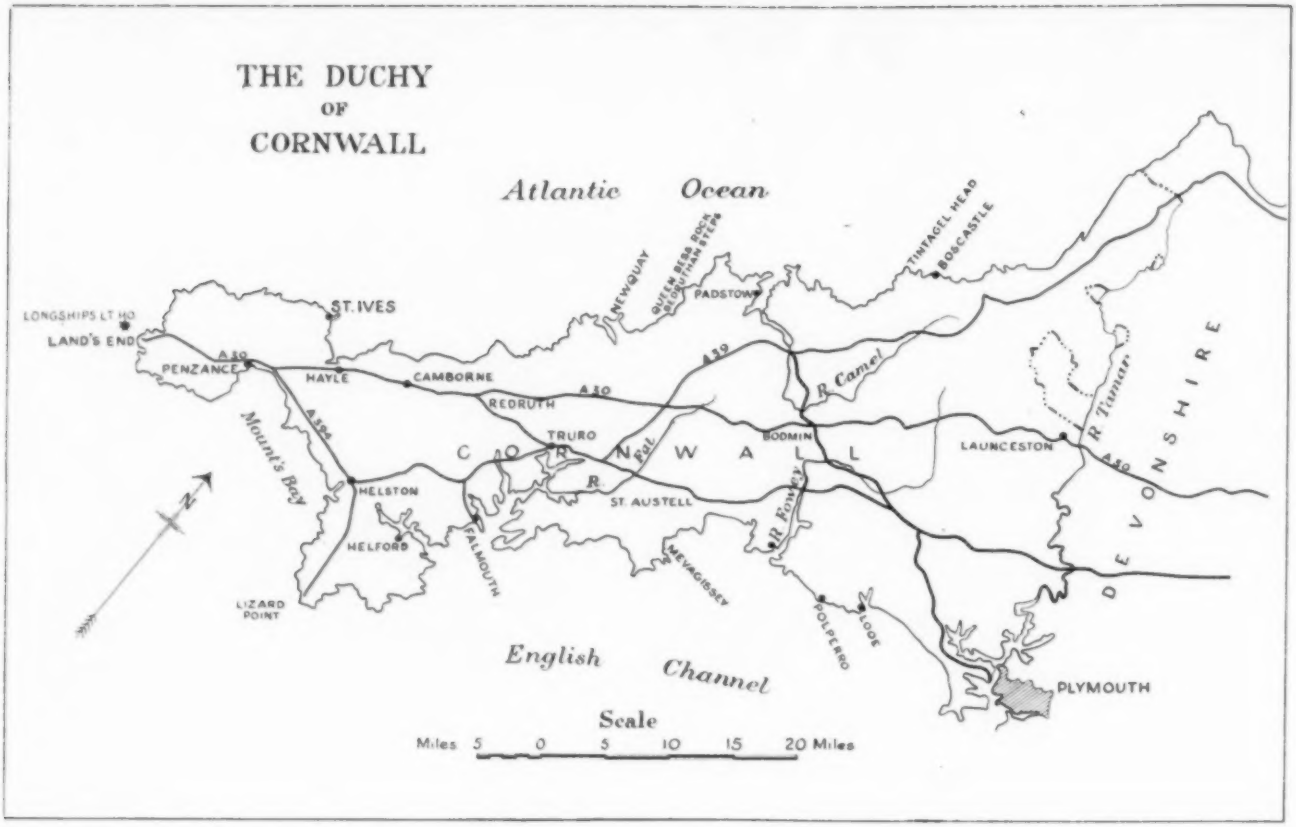
In more recent ages the rising and sinking of the land is evidenced in the raised beaches (which can be seen on both coasts) and submerged forests. In historic times sands have

One of the many picturesque Cornish harbours, Polperro, with houses perched on the hill-side overlooking boats and water.



Cornwall's rugged west coast, a fortress of granite against the pounding waves and howling gales of the Atlantic. Among the region's scattered monuments to the past are its ruined tin mines, Tintagel Castle (now mouldering on a cliff), and ancient sites hinting at the unknown lives of prehistoric men.

Rosemary Gilliat



blown across the shore and covered some coastlands with dunes to heights above roof-top level of the local buildings. And some say the sea has gained sections of the country in compensation, for example the sunken land of Lyonesse between Land's End and the Scilly Isles. But this belongs more strictly to the realms of legend in which Cornish history abounds.

This great mass of rocks, known as the Duchy of Cornwall, forms 866,000 acres of the island of Britain, but has as little as possible to do with it. It shares a boundary with only one county, Devon, and is unique in that respect, for no other county in the kingdom is bordered by less than three others. For the rest, it is surrounded by the sea and even its border with Devon is largely water. It is chiefly that of the Tamar River which rises in the far north-east of the county only some four miles from the sea and flows in a series of twists down to the English Channel at Plymouth. Except for a very few miles, Cornwall is an island.

The fact of the sea haunts and shapes its existence. No point within its boundaries is more than twenty miles from the sea; it has the longest coastline of any county in England, though it is by no means the largest county. The climate, as might be expected, is a maritime one. Cornwall lies in the direct path of the rain-bearing Atlantic winds and gales. It

The rural intimacy of Altarnum contrasts strongly with the barrenness of adjacent Bodmin Moor.

therefore knows wet tempestuous weather in its exposed places. But it lies also in the path of the warm currents from the Gulf Stream. So it experiences a mild climate where snow in winter is almost a total stranger. The south is slightly warmer, but great differences are recorded at points along the coast depending on the aspect of the coastline and the shelter it affords.

This is a very diverse seashore. The north is generally wild and precipitous, its bare cliffs rising out of the water to an almost perpendicular 200 feet. The shore is characterized by sudden and prominent headlands which often harbour between them beautiful stretches of yellow sands. The south has a gentler inclination. It is a green land pierced by deep estuaries and winding inlets, which in turn are varied by creeks. The estuaries of the Tamar, Looe, Fowey and Fal Rivers are tidal for long distances, reaching eleven miles in the case of the Fal. Many of the estuaries are old drowned river valleys or rias invaded by the sea at the time of the land's sinking. They can often take large ocean steamers, especially when dredged as, for example, at Fowey.

The land varies also from east to west. Its highest point is reached near the Devon border by Brown Willy, part of the furze and heather-covered granite mass of Bodmin Moor, 1,375 feet above sea level. Westward the heights of the moorlands decrease and their wild grandeur changes to the barren but exciting rock surface of Land's End.

Life is quiet in Polperro and the village seems to drowse serenely in the sunshine.

Cornwall has a high percentage of rocky ground, indeed it tempts a description as one vast rock. Much of it is agriculturally unproductive, especially where the poor drainage of the moorlands cannot cope with the heavy rains and leads to an excess of acidity in the soil. Average rainfall varies from thirty-two inches in Scilly to as high as sixty inches on the eastern moorlands. But in the lime and salt regions of the Devonian rocks, cultivation is possible. The main form of land utilization is stock-rearing, wherever dampness and mild weather are conducive to good grassland.

This mild weather, besides its intrinsic pleasantness, gives to Cornwall an advantage over the rest of the country in the production of early fruits, flowers and vegetables. Market-gardening is an important part of the Cornish economy. As early as December and until the

Artists find the peaceful Cornish fishing villages irresistible subjects for their brushes.

spring almost the entire population of Scilly is engaged in gathering and packaging flowers, and this occupation has spread to the west coast of the Cornish mainland.

In the more sheltered places in the county the climate makes possible a vegetation which for Britain is quite exotic. In the south-west banana and orange trees are found growing with a large selection of sub-tropical plants such as myrtle and hydrangeas. Even on the more rugged north shore palms are found. In other areas the land is arable, growing barley, oats and cattle-fodder. The west supports dairy herds, pigs and poultry, and in the east sheep are raised.

The land has not been Cornwall's only source of wealth; the local waters have provided fishing grounds of great importance. Unfortunately the past tense must be used, for in recent times fishing has suffered a serious decline. The fate and prosperity of coastal settlements has naturally been bound up with the history of fishing. There is little doubt of the industry's antiquity. Already, by the Middle Ages, the fisheries were prosperous. Villages sprang up all round the coast in which the working population was composed almost entirely of men who fished not only the local waters, but travelled farther afield, until in subsequent centuries they worked across the Atlantic as far as the Newfoundland grounds.

The height of prosperity was achieved in the nineteenth century in the fishing and marketing of pilchard, herring and mackerel. Various methods of catching fish were used, the most popular being drifting and seining. The latter, an inshore method, was in use as early as the reign of Queen Elizabeth I. It yielded annually an abundant catch of pilchards which swam in close to the coast. In 1834 the colossal haul of 30,000,000 pilchards was recorded in one hour at St. Ives!

Seining has finished since the shoals have ceased to come close inshore. Drifting suffered a severe blow from the competition of the highly organized, big business drifters of England's east coast. The Cornish way of life has usually favoured individual enterprise. The fishermen possessed their own boats and worked co-operatively sharing the profits rather than serving an impersonal employer.

This streak of Cornish individuality is reflected throughout the history of the county. Though it is geographically part of England, to which it has been politically united for a thousand years, it has yet contrived to maintain a certain separateness which the passing of centuries has never finally eradicated. This is exhibited in many ways and is due to a multiplicity of factors.

Chief among these are the features of the terrain. The types and qualities of the rocks determined the character of early settlement and the distinctive occupations of the settlers. The situation of the rock masses and valleys affected the lines of communication and led to the comparative isolation of the region. The consequent segregation has to a large extent preserved the purity of the racial strain, the features of its folk-lore, religious life, speech and customs.

Cornwall was among the first areas of settle-

The vast pyramids of the china-clay industry tower above the moors like the shining mountains of another world.

Small and spare, solid and practical, the Cornish farmhouse seems to be rooted in the landscape—as grey as the surrounding rocks from which it is built. There are few trees along the wind-swept coast, so wood is scarce. Farmers build fences of stone and improvise gates of wheels or old iron bedsteads.

Rosemary Gilliat

ment in Britain, peopled in paleolithic times by emigrants from the Mediterranean who lived on the heights at the western extreme of the peninsula. By the New Stone Age it was probably well populated and the signs of neolithic settlement — monuments such as dolmens, barrows and stone circles — have stood to this day against the passage of 5,000 years or more.

So life continued throughout the succeeding centuries to the Bronze Age about 2000 B.C. with a rising standard of civilization. Locally-made axes have been discovered with their casting moulds besides jugs, gold ornaments and imported luxury wares from Ireland. The move towards farming had begun with terraced fields on hill slopes. The Cornish moors seem to have been drier about this time than they are today, which probably explains the growth of Bronze Age settlement during the warm dry summers and the spread of farming and stock-raising.

In the fourth century B.C. the warlike Celts of the Iron Age invaded the territory, besides other sections of western Britain, conquered the original inhabitants, settled on the land and intermixed with them. They built hill-forts and cliff-castles as defence during wars, but carried on peacetime life in small villages such as that of Chysauster, now unearthed on the western slopes near Penzance. Many traces of Celtic life have been found, including pottery, querns and whetstones, flints, iron weapons and smelted tin.

As early as prehistoric times tin, a necessary ingredient of artifacts of the Bronze Age, was worked in Cornwall, apparently by Irish and Breton prospectors, and the product entered

Palm trees, which grow readily in the warm south of England, flank the tower of the Church of St. Charles the Martyr at Falmouth in Cornwall.
Rosemary Gilliat

into primitive international trade. It was the attraction of tin resources which most likely brought the Celt invaders from the west of France and the Iron Age forts already mentioned were probably used to maintain security of the tin trade. Ancient tin slag-heaps have been discovered at Chûn Castle in the west.

Tin production was then open-air work, alluvial ores being uncovered with picks from the gravel and sand-layers on the moors or in the stream-beds. About the third century A.D. a fillip was given to the industry by the decline of Spanish tin production. But it was not until the Middle Ages that mining became a factor in the extraction of Cornish tin.

By the fifteenth century the river-bed ores were becoming worked out, so attention turned to the metal veins in the cliff sides and soon Cornishmen were removing tin with their hooked sticks from small square tunnels bored into the cliffs of the northern sea coasts. Mines became deeper and machinery began to play its part in helping to extract the ores. By the middle of the nineteenth century this small county was producing one half of the world's tin and three quarters of its copper. A hundred years before, the rich copper deposits of the lower strata had been noticed and gave a further impetus to deep mining.

With dramatic suddenness a decade or two later, the tin industry suffered a severe blow from Malayan competition. There the tin was produced more economically by dredging instead of mining. A very few Cornish tin mines are still in operation in the Redruth area, their product used for coating the metal of food-cans and by the British automobile industry for some car components. But the ever optimistic inhabitants believe their day will return, when the surface deposits in Malaya have become exhausted, for there is still a vast amount of tin left under the county. They will have to wait many years before this comes to pass, but what is time in a region that already had a long significant history behind it before the Romans first invaded Britain 2,000 years ago!

One of the few places on the island which the Romans failed to conquer and occupy was Cornwall. The poor state of communications across exposed moorlands or through almost impenetrable river valley forests was no small contributing factor. All the same, the many Roman coins found in the areas near the coast indicate peaceful trading in tin. Cornwall held out for many years against the Saxon invaders, and almost alone preserved the Romano-Christian tradition in Britain before Augustine converted the Saxons themselves. Final Cornish defeat by Saxon settlers in the ninth century still left the county more or less free and independent.

It was with the Norman conquest in the eleventh century that Cornwall experienced the tying of the first knot between herself and England, not to her liking perhaps. The more thorough occupation of the Normans was supported by the construction of castles and churches, an activity that stimulated another Cornish industry. This, the quarrying and use

of Cornish stone, has persisted to the present day. Granite was too hard to carve in Norman times, so the colourful Lizard serpentine and softer St. Austell district stone were quarried. Cornish stone is used in some of London's river embankments and some southern English roads.

The medieval period was not an exceptionally notable one in Cornish history, though Cornwall shared in the economic development of the thirteenth century. In 1337 it was created a duchy by Edward III for his son, Edward, the Black Prince. (Ever since, the eldest son of the sovereign has received this dukedom by inheritance.) At the end of the Middle Ages, the West Country came to the forefront in England's affairs, when the nation turned its attention toward the Atlantic Ocean. Soon a new class prospered in the county. The gentleman adventurer, the independent merchant, superseded the landed nobility in public affairs and at the court of the first Queen Elizabeth. The men who looked to the sea were the men who mattered. Thus the Atlantic maritime counties of Cornwall and Devon saw the growth of their harbours in size and number, mainly along the easily accessible south coast. Falmouth and Fowey were able to accommodate the big ships of the Elizabethan era, as indeed they can harbour the ocean-going vessels of today.

The overland routes still had to await improvements. The few ancient trackways ran along hill-tops from the centre of the Devon-Cornwall border. The first bridge over the Tamar River boundary was not built until after the Norman conquest. Roads were in extremely bad condition and much land trade was conducted along mule tracks. The first wheeled coaches of the seventeenth century made a worse mess of the roads, but in the next century the turn-pike was instituted, and with the toll-fees collected improvements were made sufficient to enable the first stage-coach runs into the duchy. At that time it took two weeks to complete the 300 miles from London to Falmouth, but by 1800 the journey could be achieved in two days.

For centuries sand has drifted in the storied region of the River Camel. The ancient Church of St. Enodoc was buried to the steeple for over 1,000 years.

It was with the coming of the railway that Cornwall's general isolation was broken, and Brunel's great railway bridge over the Tamar in 1859 terminated it. The part played by Cornwall itself in the development of this form of transport was a major one. Steam-engines had been devised to pump water out of deep mines and Watt's engine was tried out in Cornish tin mines with great success. But it was a local man, Trevithick, who improved the machine to the point which made steam-engine locomotion a practical project. He also ran the world's first locomotive in the streets of London in 1803.

Cornishmen took to engineering as naturally as they had taken to the sea and there was hardly a part of the world where the beginning

The interior of a thirteenth century Cornish church, showing the "wagon-roof" typical of the region.

The region where the River Camel flows out to the Atlantic Ocean is involved in the legends of King Arthur. For centuries this section of Cornwall has been invaded by sand which blows and drifts and sometimes buries entire buildings.

of mechanical development was not accompanied by the sound of a Cornish voice. The tradition is continued to present times within the county by its manufacture of mining machinery for export and its important engineering school at Camborne.

In spite of all this, it must be admitted that Cornwall has suffered much bad luck. Nature and geography endowed her with numerous resources which made her eminently suitable for a great variety of prosperous occupations. But her fishing and metal-mining have been seriously affected by modern large-scale competition elsewhere and her stone and slate-quarrying, engineering and agriculture have remained small-scale in scope.

In one industry, nevertheless, Cornwall enjoys prosperity — the kaolin or china-clay industry. Kaolin was first discovered in Cornwall in the mid-eighteenth century. Its main centre is now the St. Austell district. The clay is produced by the decomposition of the softer felspar in granite. Other elements in granite, such as mica and quartz, have to be removed to ensure the purity of the clay. This process is carried out in the clay works on the moors around St. Austell. They are now a region of pits, often a mile in circumference and about 300 feet deep, with great pyramids of whitish waste reaching the same height at their heads.

Remarkably enough, these pyramids — sometimes romantically referred to as the "mountains of the moon" — are not so unsightly as might be imagined and exercise a certain fascination for the visitor. For local people they have a similar fascination, but for a different reason: they are monuments to the region's prosperity. Clay is in great demand all over the world, by the English potteries, by paper manufacturers who use about three-quarters of the produce, and as an ingredient in the making of medicines and dyes.

Yet if the kaolin industry failed tomorrow I do not believe it would spell disaster for Cornwall. The duchy has an astonishing faculty for the timely discovery of a further natural resource, which it quickly turns to its economic advantage.

EDITOR'S NOTE-BOOK

W. J. Mackey (*The International Geophysical Year*) is in the public relations section of the National Research Council of Canada, Ottawa. There his work has brought him into close touch with preparations for the International Geophysical Year (July 1957—December 1958) and the Eleventh General Assembly of the International Union of Geodesy and Geophysics, which is to be held at the University of Toronto this September. Formerly he was associated with Ontario research organizations in Toronto.

* * *

Lyn Harrington and Richard Harrington (*Waterfowl Research at Delta, Manitoba*) have frequently contributed striking pictorial articles on Canadian and foreign topics to the *Journal*, she with her pen, her husband with his camera. Inveterate travellers, they have ranged far and wide over the world, recording their impressions vividly and dealing with a great variety of subjects.

* * *

His Excellency The Right Honourable Vincent Massey, C.H. (*Everyman His Own Geographer*) Governor-General of Canada and Honorary Patron of the Society, honoured us in February by giving an address at our Annual General Meeting. His Excellency's mastery of language, scholarship and wit made the occasion one that will live long in the memories of all who heard him, both at the meeting and later over the national network of the Canadian Broadcasting Corporation. The text of the address is published in this issue.

* * *

S. G. Joseph (*The Duchy of Cornwall*) is a freelance writer who lives in Sussex, England. His interesting studies of the British scene have appeared in various publications.

Scholarship For Study In Sweden

The Swedish Institute in Stockholm and the Government of Sweden, offer a scholarship to a Canadian student for study in Sweden. Preference will be given to a candidate who wishes to pursue a programme of study on the post-graduate level. The scholarship holder may spend up to eight months in Sweden during the period September 1957—May 1958.

The scholarship will cover tuition fees and living expenses for the academic year. In addition, approximately $450 travel expenses will be paid in two instalments, on arrival in Sweden and before leaving that country. The candidate must submit to the Swedish Institute a report on his or her work in Sweden before leaving.

An application, containing information on past studies and proposed work in Sweden should be sent, not later than 1st May 1957 to The Canadian-Scandinavian Foundation, 539 Pine Avenue West, Montreal, Que.

The IGU Newsletter

Twice a year (in January and July) the International Geographical Union issues a publication called *The IGU Newsletter*, which contains information about the Union, its commissions, international activities and geographical development in various parts of the world. Articles are printed in English or French, the two official languages of the IGU, except in special cases. Important announcements, statutes, and so on appear in both languages.

The National Committee of the IGU sends the publication free of charge to geographers and geographical institutions in member countries. Others may receive it by applying to the Secretariat of the IGU, 30 Freiestrasse, Zurich 32, Switzerland. The subscription rate (1957-60) is $4.

AMONGST THE NEW BOOKS

I Brought the Ages Home

by C. T. Currelly

(Ryerson Press, Toronto. $6.00)

This is the fascinating story of one man's adventures in many countries, searching for priceless antiquities, and the gathering of these antiquities into a great museum. Dr. Currelly is famed as the first curator—and the creator — of the Royal Ontario Museum of Archaeology, one of the most important museums in the world. But even those who have never heard of him, and who shun museums on principle, will find this personal narrative of his absorbingly interesting.

(Continued on page VII)

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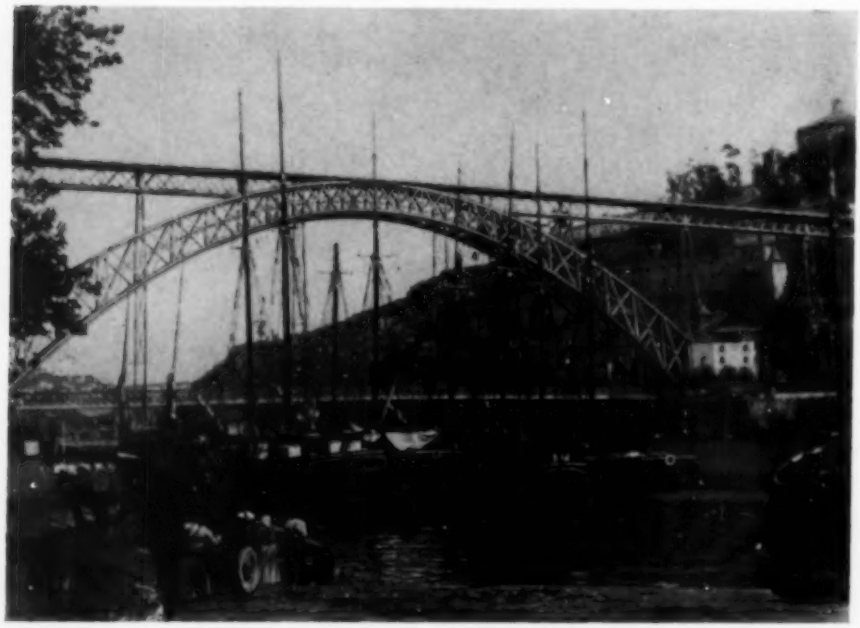

Portugal will soon be linked with Canada by a direct air service between Lisbon and Montreal and Toronto. The Don Suiz bridge across the River Douro from Oporto to Villa Nova de Gaia, Portugal. Mabel Foster

Canadian Air Service to Lisbon

On 1st June Canadian Pacific Airlines will inaugurate flights from Toronto and Montreal to Lisbon, Portugal. It will take twelve hours to travel from Montreal to Lisbon, fourteen from Toronto with a stop at Montreal. There will be two flights a week. Tourist fares, one way, from Toronto will be $310, from Montreal $291. First class fares will be $466 and $442 respectively. It is hoped that, with the completion of bilateral agreements between Spain and Canada, the flights may be extended to Madrid.

New Hotel at Acapulco, Mexico

Mexico is still being described as the place where fewer dollars will buy more than anywhere else in North America. Its tourist business has been growing now for a decade. Large and elaborate hotels have been opened in Mexico City and Acapulco. The latest addition to these is the luxurious new Pierre Marques Hotel on Revolcadero Beach, a fifteen-minute drive from the centre of Acapulco. All of its 104 rooms face the ocean and have balconies. Double rooms with bath cost $25 to $31 a day without meals. The hotel also owns and rents three cottages.

Otter Lake Music Centre

The Otter Lake Music Centre at Round Lake, Weir, Quebec (about seventy miles north-west of Montreal) will be open this summer for its fifth season, 30 June - 21 July. As usual, courses are offered for amateur and professional musicians. There will be instruction in choral singing, recorder playing, chamber music, lieder singing, madrigals, choral conducting, composition, and folk dancing. Mornings are devoted to classes, afternoons to recreation, and evenings to concerts. Further information may be obtained from the Secretary, Otter Lake Music Centre, P.O. Box 195, Outremont, Quebec.

Flying Fishermen in Saskatchewan

In August for the ninth year Saskatchewan Government Airways will offer fishermen flights into the wilderness of Saskatchewan's North. Aircraft will be based at La Ronge, 172 miles north of Prince Albert, where motorable roads cease. Fishermen may be taken to any of a dozen or so fishing camps between La Ronge and the Churchill River system. Last year more than 1,000 took advantage of this service. In Lake Athabasca one of them caught a lake trout

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weighing eighty pounds. This is said to be a world record.

Canadian Public Holidays 1957

The Queen's birthday and Thanksgiving, the only holidays fixed by government proclamation in recent years, have been given permanent dates. The former will coincide with Victoria Day and will be celebrated on the Monday preceding 25 May—this year on 20 May. Thanksgiving will be held on the second Monday of October. The date this year is 14 October.

Caronia World Cruise in 1958

The Cunard Steam-ship Company Limited has announced that the *Caronia* will sail on 21 January 1958 on a world cruise lasting 108 days. She will call at twenty-three ports in seventeen countries. The minimum fare for the voyage is $3,200.

The ship will first visit Trinidad and Brazil, then cross the South Atlantic Ocean to Africa, and from there proceed to India, Thailand, Indonesia, Japan and the Hawaiian Islands. From the islands she will sail by way of the Panama Canal to New York. The cruise will terminate 9 May 1958. En route there will be excursions and inland tours. Passengers will have nine days in Africa, another nine in India and Ceylon, and a week in Japan.

Amongst The New Books

(*Continued from page V*)

Dr. Currelly was active in Egypt when some of the great finds were being made. He had the signal honour and good fortune of working under the celebrated Egyptologist Sir Flinders Petrie, and his story of how royal tombs and treasures were discovered is one of the most thrilling parts of the book. He seems to have been favoured time and again with amazing good luck.

He tells how, for instance, one day when he was sailing up the Nile in a house-boat, "a man beckoned from the bank and came on board, and opened out a small parcel of things that he said had been found together. There was a short sword, a bottle of wound glass—made long before the days of blown glass—and a couple of pieces of glazed fruit. He told me where they had been found. I tried to keep my face as dead as possible, and started the usual lengthy bargaining, obtaining the lot for a small sum. The sword had a bronze blade, an ebony and gold handle, and an alabaster pommel, in the top of which was a gold cartouche with a name. It was the sword of Aahmes I, the Pharaoh who knew not Joseph, and it had been found near to where I had discovered his great tomb and temple during my first year in Egypt. This was one of the finest objects I ever obtained in Egypt".

Another time, Dr. George Crofts, the celebrated collector of Chinese treasures, happened to pick up in Toronto a postcard someone had dropped, showing a rare pottery figure of the T'ang dynasty—which Crofts himself had sent to London years before! The postcard stated that the figure was now owned by the Royal Ontario Museum, so he made a visit there to see what else the museum had. "As it was through him," writes Dr. Currelly, "that we received over ten million dollars' worth of material, and were lifted by it to the position of one of the world's great museums, I feel that my meeting with Crofts was one of the two most important things that have happened to me and the museum, the other being my first meeting with Petrie".

This led to a further contact of great value, with Bishop White of Honan, through whom the museum obtained another tremendously important collection of Chinese material, of a period earlier than the first. "Crofts had got very little that was B. C. and White very little that was A. D., so that now both periods are well represented in the museum."

Again and again the reader is shown how invaluable *objets d'art* are acquired,—the bargaining that goes on with discoverers and with dealers, the clever forgeries that were sometimes made, so that even authorities like Petrie were occasionally taken in. One gets the impression, however, that the author's judgment was unerring. One of the curious quirks of human nature he noticed was the willingness of otherwise honest tourists to buy stolen goods because they thought they were getting unheard-of bargains. And he illustrates this by telling how a dealer in Damascus would, with the aid of a conniving guide, stage a little drama behind locked doors for the benefit of a group of tourists. He would produce a modern carpet that had been well worn, and pass it off as a priceless piece just stolen from a mosque. As it was "hot", he would have to get rid of it at once, for a fraction of its real worth. And some gullible tourist would then proceed to buy it for many times its real worth.

The book is by no means entirely concerned, however, with adventures in foreign climes. There is much about the author's early and later life in Canada, and the museum's acquisitions in other provinces, ending up with the story of the Beardmore Norse relics in its collection, which have occasioned so much doubt and discussion. Dr. Currelly defends them as genuine. One finds it harder to believe some of the other statements in his book, for example, what he says about wolves and the Rev. John Doel in southern Ontario: "As he was rich for those days and a famous horseman, the Methodist Church kept him in the wolf country. He told me that he was never nervous, and had such fast horses that there was no fear of the wolves catching him. He said he often ended a night journey by jumping the bars of a pioneer farm fence with a full pack on his heels." It is equally hard for the reader conversant with western history to swallow the statement that Rev. George McDougall, the western missionary, "saved us from that horrible succession of Indian wars that were so serious in the United States."

These however, are unimportant

(*Continued on page VIII*)

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(Continued from page VII)

asides that have nothing to do with the book's main theme. Dr. Currelly gives great credit to people like Sir Edmund Osler, Sir Edmund Walker, Dr. Sigmund Samuel, and Mrs. H. D. Warren, who helped so generously in building up his collections which have since become world-famous.

CLIFFORD WILSON.

* * *

A Picture History of Canada
by Clarke Hutton
(Oxford University Press, Toronto, $3.00)

The outstanding merit of this *Picture History of Canada* is its forthright and vigorous presentation. The pictures go hand in hand with the clearly printed text, which has the direct appeal of simple, short statements of fact without comment. The brightly coloured pictures start by showing the proximity of the northeastern coast of Asia to that of Alaska, and the ease of passage whereby the migrating Asiatics could become the first new Canadians. The building of canoes in which this ocean passage was effected is shown with an intentional crudeness of line and colouring that fits the subject admirably. In the same way the pictures of home life and hunting teach by their very directness; the absence of detail stresses the urgency of considering only the prime necessities in the early days of bush life, and the style adds emphasis to the text in demonstrating the near presence of danger all the time, as well as the lack of the finer comforts of life in early pioneering days. By omission of detail the book attains an extraordinary comprehensiveness in its sixty-two pages. All the great names, both French and English, from Cabot in 1497, onwards, are faithfully dealt with. Also the Vikings and the Eskimos have their place as do the Jesuit Fathers, the Hudson's Bay Company, the United Empire Loyalists. One sees the bitter truth from which the children's game of "cowboys and Indians" took its bloodthirsty rise. Then the prohibition of slavery, the coming of the first railways, the Klondike gold rush are all worked into this story, so conspicuous for its clearness and brevity.

This book should certainly bring home to young readers the eternal verity that each generation stands on the shoulders of the generation before. Pioneers of the bush are now replaced by pioneers of scientific invention who carry on the great work of building the living history of their country to meet the demands of tomorrow.

SYLVIA SEELEY.

THE CANADIAN GEOGRAPHICAL SOCIETY

ANNUAL GENERAL MEETING

The twenty-eighth Annual General Meeting of The Canadian Geographical Society was held on 21 February 1957 in the Lecture Hall, National Museum of Canada, Ottawa. The President, General H. A. Young, presided over the meeting.

After approval of the minutes of the twenty-seventh Annual General Meeting, General Young reported on the activities of the Society during 1956. The year was considered to have been an exceptionally good one. There had been various indications of increased interest in the work of the Society throughout Canada. One important contributing factor had been the address by Dr. Leonard Brockington, entitled "Canada and Geography", which was delivered at the last Annual General Meeting and was carried on the trans-Canada network of the Canadian Broadcasting Corporation. There also had been heartening references to the work of the Society by members of Parliament in the House of Commons.

During the year the Society had endeavoured to improve its financial position by a threefold program. In January 1956 fees had been increased to $5, and in order to obtain a closer knitting of the Society's membership arrangements with subscription agencies were discontinued in July and applications for membership were taken only through the Society itself. This change in policy was considered a good test of the interest of members in the Society and had proved successful. At the end of December there were 10,437 paid members. A concentrated effort to increase membership was planned for 1957. The President thanked all Fellows and members who had played an active part during the year in extending membership either by taking out gift memberships or by submitting nominations to the Society, or who had taken the initiative by inviting their friends to become members. It was hoped that through such active participation the membership roll might be increased to 20,000 during the current year.

The second feature of the campaign had been an endeavour to increase advertising. The President said that he could report some progress in this respect.

The third and very important feature of the campaign had been the Extension Fund. The President reminded those present that the Federal Government had authorized the claiming of donations to this fund as income tax deductions. To date some $28,000 had been received. The appreciation of the Board was expressed for the contributions so generously donated by companies and individuals. The ultimate objective of the campaign was half a million dollars.

Warm acknowledgement was made by the President of the regular support and assistance of members of the Society's various committees, the services of the Editorial Committee in maintaining high standards in the *Canadian Geographical Journal*, and the work of the executive secretary and editor and the permanent staff.

He reported that a marked interest had been shown in the Society across Canada and said that it was gratifying to know that the Society's official monthly publication, the *Canadian Geographical Journal*, while maintaining its reputation as a work of reference, appeared now to have become a family magazine. There was also a growing demand for reprints of articles published in it. During 1956 twenty-five separate articles had been reissued in booklet form, bringing the total number of reprint booklets published during the Society's existence to over six million. There had been such a demand for *Image of Canada*, edited by the Society and published by the Ryerson Press, that three editions had been sold out and a fourth was in preparation.

In the absence of the Honorary Treasurer, Mr. A. G. Mordy, his report was read by Mr. E. S. Martindale. Dr. Arthur Beauchesne then submitted the report of the Nominating Committee. Ten former Directors were re-elected.

The President announced that the Board of Directors would meet in the Lecture Hall following the Annual General Meeting. He then introduced the speaker, His Excellency The Right Honourable Vincent Massey, C.H., Governor-General of Canada, and Honorary Patron of the Society.

His Excellency delivered a thoughtful and stimulating address on the significance of geography, pointing out that a knowledge of geography was basic to most human arts and emphasizing the importance of the work of the Society. The address was recorded by the Canadian Broadcasting Corporation and was broadcast over the national network later the same evening. (The text of the address is given on page 160.)

General A. G. L. McNaughton warmly thanked His Excellency for his interesting and instructive address and said that he felt that those who had heard it would profit greatly from it. He remarked that His Excellency spoke from an intimate knowledge derived from extensive travels in the far-flung regions of the country and from first-hand experience in geographic investigations. For these and many other reasons, it was especially satisfying to have had the privilege of hearing his address.

After a few introductory words by the President, two colour motion pictures, produced by Crawley Films Limited, were shown. These were *The Legend of the Raven*, dealing with Eskimo soapstone carving, and *Sky Watch on 55°*, dealing with the construction of the Mid-Canada Defence Line. The latter film was sponsored by The Bell Telephone Company of Canada and was made available to the Society for the evening through the courtesy of that company.

Immediately after the Annual General Meeting the Board of Directors met to elect officers and appoint Standing Committees for 1957.

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Location and Space-Economy

by Walter Isard

(John Wiley and Sons, Inc., New York, $8.75)

In a broad sense, this book is about the interaction of technology and geography. Where people live, how they connect up with the many services vital to modern civilization, and why some urban communities wax while others wane, are matters of importance to a country as a whole. To probe them is tantamount to an expression of faith that they can not only be understood but brought under some measure of control. Paradoxically, or so at first it seems, control is of greater moment in a free society than in an oligarchy. West of the Iron Curtain, an industrialist with an urge to manufacture safety-pins cannot simply choose a good site and then draft labour to live around it. He has to weigh countless pros and cons for each of a number of possible locations. Over the years an expertise in these things has been growing, and there is now "a general theory relating to industrial location, market areas, trade, and urban structure". This in fact is the subtitle of the book before us.

A friend riffling its pages commented wryly that "the mathematicians have sure gotten a stranglehold on economics nowadays." I have since, I hope, persuaded him that economics, like any other science, is helped, not hindered, and much less strangled, by a judicious application of mathematics. If an economic problem can be shown to fit—imperfectly, of course— a mathematical framework, then there is reason to believe that prediction and planning will be facilitated. This is borne out in Dr. Isard's work, whose mathematical formulation of general location theory is judiciously confined to one of his ten chapters. The bulk of the book is in standard English interspersed with excellent diagrams and needs only common sense to be followed.

Until fairly recently discussion of regional economy was characterized by a stress on its temporal rather than spatial conditioning. The author points out that English-speaking economists had overlooked the German school, whose dean was Alfred Weber, author of a perspicacious treatise on the location of industries in 1909. His approach was evolutionary, in the sense that he set out to examine the forces, shifts, and developing interactions that accompany the growth of an isolated economy from zero (which is the initial occupation of the area) through the purely agricultural stage to a complex industrial society. A landmark of the German school was the 1944 appearance of a weighty volume by Lösch in which a formalized treatment of the subject is used for the first time. Lösch's work forms, as it were, the base-line from which Dr. Isard's conceptual analysis begins. He is rightly concerned to synthesize location theory and production, and although he admits that much is still to be done, his present investigation plainly shows the road to be taken. The pay-off should be a firmer basis for decisions in such fields as city planning, land usage, and marketing operations.

The book itself, it should be added, is finely produced. It also has the most comprehensive subject index I have seen in years.

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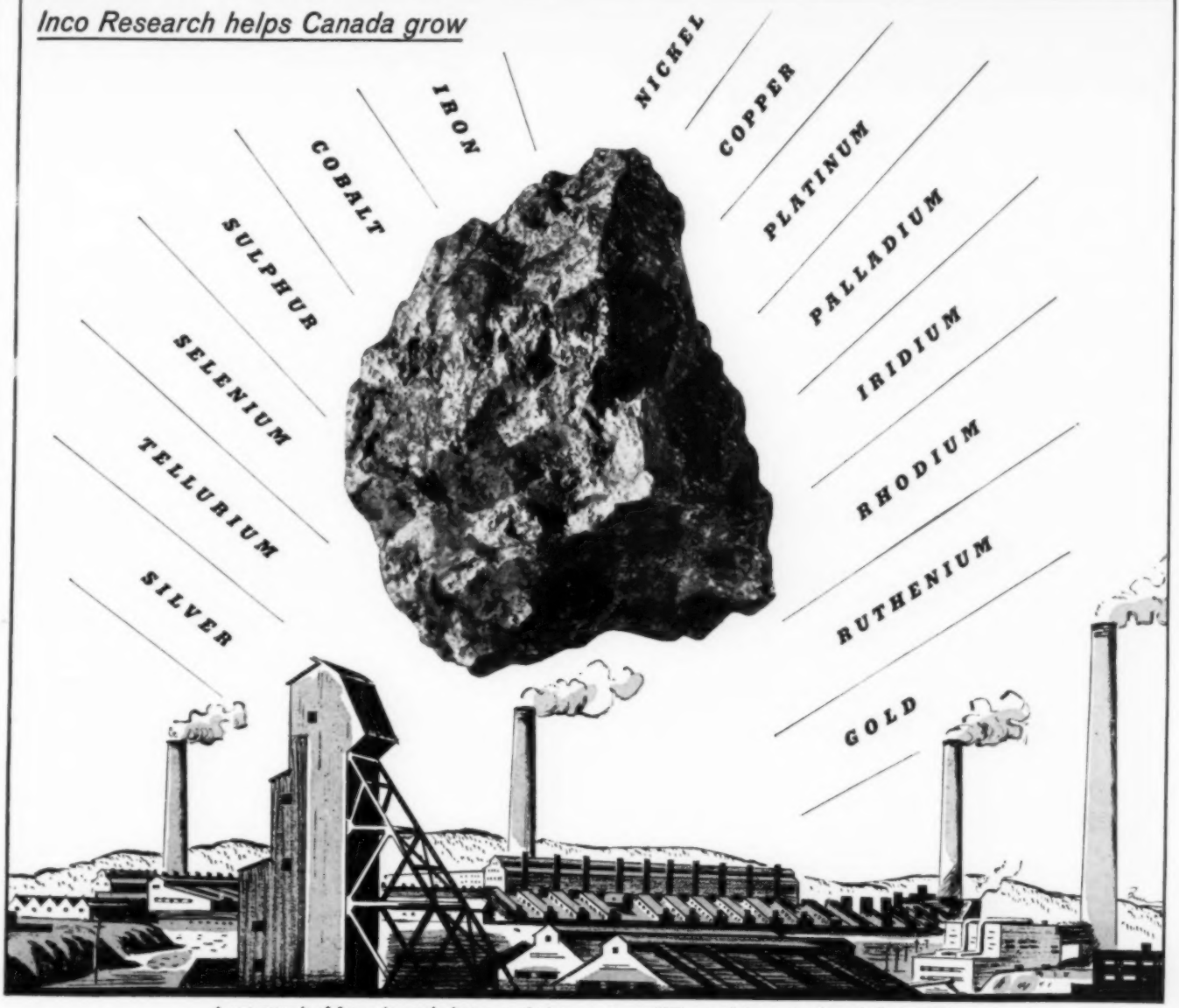

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Fundamentals of Economic Geography

by Nels A. Bengston and Wm. Van Royen

(Prentice-Hall Inc., Englewood Cliffs, N.J. $8.70)

Among the various divisions into which geography is commonly divided, economic geography is one of the more difficult about which to write. In the modern world, economic conditions may, and indeed almost certainly will, undergo great changes in a comparatively few years, thus soon rendering any textbook out of date. Perhaps no similar period in history can show more numerous or more significant changes than those which have taken place in the twenty-one years since the first edition of this book was published. In a valiant effort to keep pace with the times, the authors have produced the fourth edition, amidst world-shaking events which presage far-reaching readjustments in global commercial patterns as well as in other phases of international relations.

The first edition of this book might, perhaps, be called the pioneer of modern economic geographies. At its introduction it was hailed as unique — yet thoroughly orthodox, economic—yet almost general in scope, and readily adaptable to both purposes, and reviewers predicted that it would enjoy wide popularity. That this prediction was accurate, is attested by the fact that the book has gone through three editions and the publishers deem it worth while to launch a new edition in the face of stiffening competition in the field.

The general organization of the book, except for certain minor but significant changes, follows the pattern so successfully used in the earlier editions. The introductory chapters are devoted to discussion of various aspects of human geography, the field and function of economic geography is defined, and considerable emphasis is placed upon the relationship to the natural environment of certain aspects of economic activity, with climate and soil being accorded rather extended treatment. Following upon this, almost one-third of the book is devoted to descriptions of the various climatic regions and the productive activities which are more or less under climatic control, such as grazing, agriculture, and forestry.

Approximately one-third of the book, also, is given over to discussions of mineral and power resources and the industries to which they have given rise. Coal, petroleum and natural gas, water-power, iron and steel, and non-ferrous metals are emphasized, while the modern viewpoint of the authors is expressed in a new chapter on the geographic implications of the nuclear energy minerals.

In the closing chapters certain selected industries, including textiles, chemicals, and machinery, are discussed, the industrial de ice of certain American and E an r gions is stressed, and a 'er given to transportation. the authors set forth their of geography by pointing is expected to answer four (1) What is the fact? (2) W it occur? (3) Why does it occu (4) What does it mean? A fu statement of their geographic phil phy is contained in this senter "Broadly speaking, the distributio of population is directly related t environmental factors among whic man himself must be reckoned."

As was the case with the previou edition, this one is profusely illus trated with photographs, diagrams, and maps. On the whole, the carto graphic treatment shows improve ment over that of the former edition, and, in most cases, incorporates the latest data available at the time of draughting. One or two unfortunate slips, however, may be noted. For instance, the diagram on page 136, showing the origin of the bananas sold in the United States, is clearly in error. There are, also, some maps, such as that on page 217, which while showing cartographical improvement in a number of ways are still difficult to read quickly because of the light lines which are used for the coast.

Being written for the American college student, one must, of course, forgive the book for dealing more extensively with American examples than with other parts of the world. Yet, since Canadian economy is so closely linked with that of the United States, one might expect that references to this country would be kept accurate and up to date. The treatment of petroleum, and iron and steel in Canada, for instance, leaves much to be desired. Oil from Alberta is piped to Superior, Wisconsin, but nothing is said of the Trans-mountain line, nor of the extension of the Interprovincial pipeline to Ontario. Plans for the exploitation of iron ores in north-eastern Quebec are "well-advanced", but, in this part of the book, Newfoundland is not even part of Canada! Kitimat receives no mention in the section on aluminum production; the Baie Comeau development is, of course, too new to be mentioned yet, but perhaps both it and Kitimat will be included in the next edition. It is, however, somewhat unfair for a Canadian reviewer to spend too much space on this sort of criticism, for a genuine effort to achieve a balanced treatment is evident throughout the book.

Taken as a whole, the work is stil a pleasing exposition of economic geography and, despite its recen competitors, it should remain in favour as a college text for a lon time to come.

D. F. PUTNAM

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Gazette
PRINTING COMPANY
(LIMITED)

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UN. 6-3561 1000 St. Antoine St., Montreal.